"EVALUATION OF SMOKE EXTRACTION SYSTEMS VERSUS VENTILATION IN SHIPBUILDING AND REPAIR . . ..."

TASK 1-85-3

FINAL REPORT

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PREPARED BY

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FOR

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FOREWORD

This research project was performed under the National Shipbuilding Research Program. The project was accomplished by BMS & Associates, under subcontract to National Steel and Shipbuilding Company. The overall objective was to define the most cost effective systems to remove welding smoke or other air pollution from shops and other enclosed (shipboard) spaces.

This study has been undertaken with these goals in mind and has fulfilled the basis of the project outline approved by the Society of Naval Architects and Marine Engineers (SNAME) Ship Production Committee.

program definition and guidance was given by Mr. W- Appleton and Mr. James Ruecker, both of National Steel and Shipbuilding Company. Direct participation and support was given by Judie Blakey, Assistant Superintendent Production Services at National Steel and Shipbuilding, and her staff. Various members of the SP-1, Panel and their staff also participated with the evaluations.

EXECUTIVE SUMMARY

The technical objective from the project abstract requires evaluations and conclusions be based upon cost effectiveness to each of the various tasks or applications. Our evaluations found that

THE COSTS ASSOCIATED WITH THE CURRENTLY APPLIED METHODS OF VENTILATION ARE DOCUMENTING SYSTEMS WITH AT BEST **30 — 40%** LEVEL OF **TRUE SOURCE VENTILATION OR EXTRACTION** OF WELDING FUMES. THUS THE DIRECTION OF THE CONCLUSIONS AND RECOMMENDATIONS WILL BE STRUCTURED TO THE TRUER OVERALL OBJECTIVE WHICH IS TO HAVE AN **INCREASED LEVEL OF SOURCE VENTILATION OR EXTRACTION, INCLUDING** IMPROVED METHODS FOR BOTH, AS WELL AS TO DEPICT AREAS FOR REDUCING COSTS FOR ANY LEVEL OR TYPE OF SERVICE.—"

The Shipbuilding Industry, with its budget constraints, will in the near future have to address increased regulatory standards for welding operations. This report is intended to be the source document for planning how to best integrate such changes into the Industry, in order to gain positive results.

APPROACH

- **Carry out proactive analysis and participation at the user level.**
- **Review operating methods of those groups which generate the associated costs, directly and indirectly.**
- **Present technical aspects of pertinent major extraction and ventilation and ventilation applications on the market.**
- **Research and document applicable government and regulatory data.**
- **Conduct and develop various trial demonstrations with vendors on applicable equipment in selected shipyard processes.**
- **Analyze and participate with the key staff at various shipyards to discuss and verify data.**
- **Report findings in a format suitable for users to apply at their own yard and under their own circumstances.**

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INTRODUCTION

Smoke Extraction versus Ventilation of welding fumes in Shipbuilding and Repair is a Imown Improvement to thee overall working environment in a Shipyard. This evaluation study was not intended to train anyone in:

- **Weld Smoke Fume Hazards.**
- **Basic Industrial Ventilation Theory and Practices.**
- **Current and Pending Local and Federal Regulations.**

The welding processes in the Shipbuilding Industry are most basic to the overall tasks involved in Shipbuilding. Welding generates various types of fumes, which are vapors of the particular material being welds some of which have more potential hazards to human health than others. The need for extraction of these particles from the times allows for cleaned air to be recirculated to the work area or into the atmosphere. Ventilation simply relocates and dilutes airflow to the atmosphere, and thus the potential harmful particles are recirculated.

The equipment reviewed during this study was also found to have excellent direct applications to other problem areas of Shipbuilding such as:

- **Tank Cleaning and Fume Removal.**
- **Mist, Odor and Fume Removal From Plating Processes.**
- **Sand Blasting and Dust Collection.**

This report will target the weld fumes, and will only reference these other application areas.

The SP-1 Panel of the NSRP required a hands on evaluation of the efforts currently in place, to determine if they are satisfactory; and in what ways. The scope of this evaluation from the projec abstract is to evaluate Shipyard practices in these areas. The underlying objective is the application of specific recommendations relative to Smoke Extinction and Ventilation in Shipbuilding and Repair.

THIS STUDY WILL:

- **Provide Technical Overviews of Smoke Extraction and Ventilation Methods and Equipment.**
- **Provide Shipyard Operational Analysis of Current Practices, Equipment and Procedures.**
- **Provide a Regulatory Overview.**
- **Provide Specific Shipbuilding Industry Recommendations for Specific Applications.**
- **Provide General Cost Analysis of Recommended Systems.**

1. CONCLUSIONS

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CONCLUSIONS OVERVIEW

The adaptation of the basic premise of PROACTIVE versus REACTIVE techniques currently employed by most yards is the main thrust of these evaluations. This will allow increased levels of utilization of the best available and most cost effective methods and equipment suited to SPECIFIC APPLICATIONS for TRUER SOURCE EXTRACTION AND VENTILATION OF WELD FUMES.

The conclusions reflect the perspective of the economic status of the Shipbuilding Industry, as well as the current and forthcoming regulatory pressures of our society. Our evaluation clearly defines a positive potential for initiating and maintaining progressive improvements with regard to the problems associated with welding fumes, via some basic PROACTIVE ORGANIZATIONAL ENHANCEMENTS, and Shipyard Managements' understanding and support of these proposals.

Each Shipyard could organizationally define a position or function for Operations and Facility Ventilation Planning and Control. (Ventilation in this case includes extraction.) This function would have full and direct responsibility for ventilation planning during all aspects of Shipyard Production and Repair, including equipment selection and control. Cost benefits and the ability of each yard to implement change varies, so by having such a dedicated PROACTIVE STAFF, changes at all levels within the total Shipyard operation could be developed and implemented. This function would be directly responsible for items such as "hot work planning", ventilation testing, ventilation equipment set-up, planning and relocation, as well as scheduling and releasing a work area for a task.

The timing of any or all possible improvements will be governed by three major factors:

1. **Increased Specific Planning For All Tasks Relating To Smoke Extraction or Ventilation Systems In Shipbuilding and Repair.**
2. **Changes in Government Regulations.**
3. **Availability of Capital.**

1. CONCLUSIONS

1.1 PROJECT RESULTS

For all applications in the Shipbuilding and Repair Industry improved equipment and methods for Smoke Extraction or Ventilation can be applied in a cost effective manner. This is due mainly to the high current cost of non-effective current systems in the Industry.

Many dollars are currently spent for various processes for Smoke Extraction or Ventilation of welding ties. But if a true measure of successful results is true source extraction, for the same dollars or a little more after recapitalization, the level of true source extraction can be greatly increased, and the ability to meet various regulations would also be enhanced.

This Project with its various on-site equipment demonstrations, " was able to provide on-the-job proof that newer equipment and improved technologies exist and that they can be applied to the Shipbuilding Industry. The timing and cost of implementation would be yard dependent. The motivation for change is often **REACTIVE,** and in this case probably dependent upon governmental regulations.

Currently a great deal of attention is being given to indoor air quality. The Industry must be very careful not to correct the indoor air quality prior to improving the production workplace. The methods and technologies, the potential for cost savings and improved work environments for health and productivity are in both cases the same. The task to fully implement is more difficult in the Production Workplace. It is strongly recommended that Production be allowed to continuously improve itself, through top level support for this action.

Various processes, shops, and applications at different yards were evaluated the conclusions are quite evident. The need for planning, education, new technology application, and most importantly for organizational positioning to implement these actions would have continuous benefits to any Shipyard. Smoke Extraction or Ventilation is a required function in the Shipbuilding Industry. To encourage a **PROACTIVE** function for **Ventilation** would be a most cost effective **MANAGEMENT STRATEGY.**

1.2 CONTINUED ACTIVITY

The SP-1 Panel could, with the distribution of this report and the planned use of the Executive Summary Letter, assure the current awareness of Shipyard Management of this activity. Specifically, top management should review the Executive Summary, and the Recommendations of this report. Proper distribution of the report within each yard should also be encouraged.

The primary conclusion and recommendation of this evaluation is for the immediate establishment of a TASK SPECIFIC ORGANIZATIONAL FUNCITION. This will be discussed with the Panel along with the presentation of the final report. The benefits from participation with the Panel will allow for the members to give and solicit Shipyard feedback and follow up on Panel Projects.

SampIing of Possible Subjects for Future Project Abstracts:

.Operating Staff Industry Seminar Workshop on Weld Fume Smoke Extraction and Ventilation Techniques and Shipyard Applications of Related Equipment.

.Shipyard Ventilation Planning System Database and Training Program.

.Panel Newsletter with Specific Governmental Activity Updates on Welding Fumes, Confined Space and Other Related Subjects.

2. PROJECT PLAN OF ACTION AND RESULTS

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2.1 PROJECT OVERVIEW

The definition of.: hat current equipment and methods of Smoke Extraction and Ventilation were utilized by the Shipbuilding Industry was the basic starting point for this evaluation. The Industry has a common organizational structure whereby ventilation is organizationally a function of a Temporary Services Group. In the Public Yards these functions are done by Dock Services.

Utilizing the Temporary Services organization at NASSCO as a base, various studies of current equipment and methods were conducted. NASSCO was also extensively involved with many Vendor equipment and process demonstrations over a period of nine months. This involved a great deal of cooperation and coordination from the NASSCO Production Services Department staff and management, of which Temporary Services is apart. Various other groups at NASSCO also participated in the actual demonstrations and evaluations of equipment for specflc Shipbuilding applications.

This Panel Project benefited from the PROACTIVE involvement of the Assistant Superintendent of Production Services at **NASSCO,** Judie Blakey.

Her support and direct involvement with Panel meetings as well as, her visits to other shipyards to review and discuss their specific equipment and methods for Smoke Extraction and Ventilation of weld fumes was most helpful. Three East Coast Facilities were visited, and the overall exchange of knowledge and common aspects of organizational functions was most beneficial to all. Moreover, there have been various follow up and communication exchanges between these parties since the original visits.

Establishing change and implementation of improvements is still the largest known problem for this Project. The Industry as a whole has the same basic budgetary constraints. Most Public and East Coast Shipyards have stiffer enforcement activity for their workers with regard to basic utilization of supplied ventilation equipment. It is an unfortunate observation, but production itself can at any time increase the quality and level of ventilation of weld smoke fumes, yet they are not self-motivated to do so.

The Vendors of equipment and processes for Smoke Extraction and Ventilation have been experiencing a boom market in Industry for their newer and improved equipment. They do not see a great market in the Shipbuilding Industry, even though there are many potential

applications. The Shipyard Industry has very few upgraded ventilation systems installed in this country. This is due mainly to the same basic constraints of budget and no absolute Regulatory policy to force the issue. The Shipbuilding Industry is traditionally **REACTIVE.**

2.2 OBJECTIVES

2.2.1 TECHNICAL OBJECTIVES

- **Review and Reference as Required The Principles of Industrial Ventilation.**
- **The Performance and Efficiency of Various Types of Fans, Blowers and Motors to Specific Applications.**

2.2.2 OPERATIONAL OBJECTIVES

- **Define Current Methods.**
- **Define Current Equipment.**
- **Define Current Operating Systems.**
- **Describe Current Planning Methods Utilized.**
- **Describe Quality of Service Provided**
- **Describe Future Equipment and Budget Planning.**
- **Discuss Equipment and Process Effectiveness and Worker Utilization.**
- **Discuss NASSCO as the Base With Inquiries to Other Yards to Verify or Enhance the Study.**

2.2.3 REGULATORY OBJECTIVES

- **NOT A PROJECT PRIORITY.**
- **CONDUCT SOME GENERAL RESEARCH FOR**
- **A COMMON REFERENCE BASIS.**

2.3 TECHNICAL DATA AND EQUIPMENT

Welding is a basic task in the Shipbuilding Industry, and the importance of creating the best workplace environment for welding should not be understated. The welding operation yields various types of fumes, vapors, mists and gases, which can be potential health hazards to those exposed. Fumes, in particular, are defined as small airborne particles formed during welding by the condensation of vapors of the solid material of the welding process. Some weld processes have a higher potential for toxic emission into the air. This report looks at simple ventilation of these weld fumes, that is moving the air steam away and diluting to the atmosphere. **THE PREFERRED PROCESS IS THAT OF EXTRACTING THESE AIRBORNE PARTICLES FROM THE WELD FUMES, AND THUSLY CLEANING THE AIR.** In both cases the air is to be removedfromthe source area. The proper application of either ventilation or extraction is being evaluated. The scope of current practice in Shipbuilding leans towards ventilation only. There are very few extraction systems installed in this Industry. Yet the Industry as a whole has a lot of room for improvement. The requirements of welding, training and set up should be expanded to include ventilation definitions.

The American Welding Society has an outstanding publication, "*WELDING FUME CONTROL WITH MECHANICAL VENTILATION,*" William C. Rous, P.E., Firemans Fund Insurance, 1981 Second Edition. Sections of this excellent report are included as an Appendix to this report. Please, now go to the Appendix for a review of this report. As stated in our introduction, we are looking to evaluate specific Shipyard applications and not educate the industry on general applications and ventilation theory.

The above AWS report should be a basic training tool for the Shipbuilding Industry, although it does not treat the newer motors or extraction equipment in great depth. This Project will lead us through Shipyard applications. It is out of respect to the quality of the AWS report that we will not go into such detail to explain basics. Finding this reference and having it available to the Industry to utilize is beneficial. The technical data of the Appendix will be assumed for the remainder of this report.

The various equipment Vendors also provide both specific application technical and cost analysis, as well as some very excellent technical manuals on Industrial Air Cleaning. In particular, "Smog-Hog" Engineering Catalog, from Smog-Hog, Air Cleaning Division, United Air Specialists, Inc., 440 Creek Road, Cincinnati, Ohio 45242 (Tel. 513- 891-0400) is very well done technically.

As equipment is evaluated for selection at a Shipyard, the particulars of the application and that facility will be most critical in the final cost. The technical evaluations can be verified with the above reference material.

THE KEY FACTORS INCLUDE:

.Flow Capture Rate At The Source.

.Motor Efficiency.

.Friction Loss Analysis.

.Recycling of CIeaned Air.

.Ducting Sizing Planning.

- **Equipment Combinations to Develop an Effective System.**
- **Equipment Cleaning Costs.**

.Pressure, Flow Rate, Distance, Volume

The requirement for a dedicated Task Functional Organization Position for ventilation/Extraction Planning must again be stated This function can save a lot of money.

2.3.1 CURRENT METHODS

Most Shipyards utilize industrial blowers or motor and fan assemblies to provide ventilation. They move air, either supply or exhaust (Source Ventilation or Extraction), via the blowers or in-house designed air blowers by attaching various sizes and lengths of industrial flexible ducting. They also develop various air movement systems by combining such with manifolds, source capture devices, hoods and other creative devices.

The following table shows some general requirements for exhausting of weld fumes from the breathing area

WELDING ZONE	Minimum CFM	Duct Diameter
4“-6” From Arc/Torch	150	3"
6"-8"	275	3 ½"
8"-10"	425	4 ½ "
10’’-12”	600	5 ½

These requirements are currently under study for revisions by NIOSH. Changes and inclusion of other regulations would encourage the Shipbuilding Industry to act quickly. Currently such levels are not consistently obtained, and various variances from code are allowed such as ventilation away from the breathing zone for dilution and then to the atmosphere. Also, the use by the worker of breathing apparatus, from a simple face mask to a fully filtered mask, and even to a separate air supply via a falter mask has been applied successfully. The utilization of breathing apparatus at the workplace only protects one worker and has tool control and set-up problems..

Most commonly utilized blowers are those manufactured by Coppus Engineering Corporation. These have proven to be the most enduring, functional, and adaptable to the industry. Yet their ability to meet the above requirements is dependent upon worker participation in continuous deployment. Worker continuous deployment of an initial setup is the single largest problem for source Ventilation or Extraction. Most of the welding tasks in Shipbuilding require constant movement of the torch or arc to the tasks. Welding in Shipbuilding is not stationary. Thus, the efforts to facilitate proper Extraction or Ventilation of weld fumes is costly, complex, and still worker dependent after an initial setup.

Most of the Private and Public Shipyards require a “sucker hose”, at any time a spark or flame is potentially present. These “suckers hoses” are usually placed anywhere from 4“ - 24” from the weld zone. They are most often a three or four inch duct, with exhaust velocity of from 50 cfm to 150 cfm. Some Shipyards augment these with capture devices which increase the cfm by 20- 30%. These often also have magnets which allow for improved movement and source capture.

The level of enforcement of having these “sucker hoses” near a work area is good at those yards with a strong policy of enforcement and warning. These disciplines are similar to helmets and safety glasses. The effectiveness of these efforts should be of great concern to the Shipbuilding Industry. These systems utilize large amounts of electricity to operate, and the suckers are often a safety hazard for foot traffic in a work area. Various studies and sampling over the years have shown that these do not continuously meet the General requirements for ventilation of the welding zone. Secondly the small percentage of fumes captured at high cost with these methods are transported from this work area and are usually released and diluted to the atmosphere. Again, it has to be noted that the worker controls the effective use of these suckers to a source once the initial set up requires movement (4” - 8“ further from the weld zone allows fumes to dilute to the atmosphere and not be effectively captured by the “sucker hose”).

Most of the ventilation methods in Shipbuilding have the same results as above. These factors have led to the accepted conclusion that the actual level of weld fume source capture for extraction or ventilation is at best 30-40%. Yet, a great deal of equipment motors, blowers, hose, capture devices, cost of initial deployment and tear down, as well as operating costs is expended daily for a 30-40% level of source capture, not to mention a probable 15:1 ratio of Ventilation to Extraction. These provide a strong platform for planning for required changes, which can, be accomplished without a straight line extension of current costs.

2.3.2 A - DEMONSTRATIONS SUMMARY

DEMONSTRATION ACTIVITY SUMMARY

TYPE OF EQUIPMENT

PORTABLE ELECTROSTATIC PRECIPITATORS

Applications Demonstrations:

- Weld School
- Sheet Metal Shop
- Pipe Shop
- On board

Options Included:

- **6 Foot to 14 Foot ArmS**
- Lighted Hoods
- Media Filter Systems
- Various Scoop Designs

MOUNTABLE ELECTROSTATIC PRECIPITATORS

Applications Demonstrations:

- Weld School Area Support System
- Pipe Shop Area Support System
- On Board - Inline Filter - (EXXON VALDEZ, AOE)

Options Included:

- 12" and 8" Hose Mounting Configurations
- Rigging Hooks For Simplified Transporting
- Blower for directing and enhancing recirculation of the cleaned air.
- Arms for Direct Source Capture
- Basic Fans For Ventilation
- The 'Ram Fan' and Aqua Powered System

Various vendors participated at Nassco with these demos. There were also for Nassco Staff various specific vendor quotations submitted for specific applications. Both the Vendors and Nassco staff were most cooperative. Also the staffs at the various other Shipyards visited and contacted as part of this evaluation.

2.3.2 IMPROVED EQUIPMENT AND TECHNOLOGIES

2.3.2.1 ELECTROSTATIC PRECIPITATORS

Below is an illustration from one of the vendors who actively participated in our evaluation, Aercology.

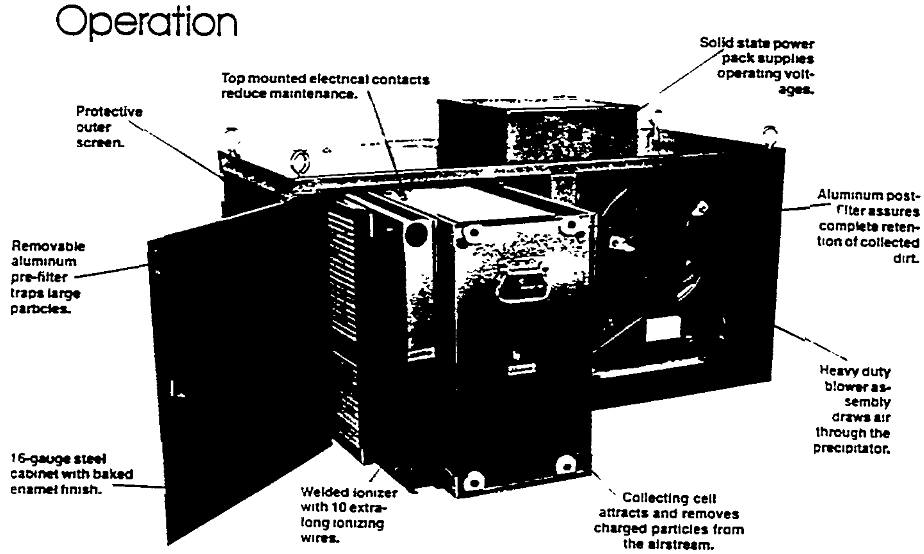
Aercology electrostatic precipitators

To complement Aercology's line of centrifugal mist collectors, a series of high efficiency electrostatic precipitators has been developed. These rugged, industrial precipitators remove airborne smoke, dust, and fumes without the need for expensive make-up plant air. The typical precipitator incorporates a pre-filter, ionizing section, collection cell, post-filter, and blower assembly to move contaminated air through the unit.

The standard, ceiling-hung configuration may be ducted to the source or free hanging, unducted. In addition, the portable model with plenum, flexible hose, and adjustable hose arm allows the precipitator to be moved around the workplace for the most effective direct capture of smoke and other contaminants.

Aercology electrostatic precipitators can do more than simply help you meet OSHA clean air requirements. The collection of mist, smoke and fumes means improved working conditions, better employee health, higher morale, and increased productivity. Lighting and maintenance costs can be reduced, too, by removing dirt from plant air before it can foul building and equipment surfaces. Low precipitator power consumption and reduced need for exhausting shop air provide big energy savings, an area of increasing importance for everyone. And Aercology does more than just market this equipment. Everything from application engineering assistance to complete turnkey installations is available. Ask Aercology.

Operation



n operation, welding smoke fumes, and contaminant-laden air are drawn through the pre-filter into the high density ionizing field which charges all dirt, regardless of particle size. Charged particles are stripped from the air moving through the precipitator and retained on oppo- sitely charged collecting cell surfaces. A post-filter is provided to entrap any particles which might blow off the cell plates. Contaminant-free air moves through the blower assembly and is discharged back into the plant through adjustable louvers.

The use of this technology with specific applications in various industries and processes has expanded greatly over the last 10 years. Shipbuilding has only two major applications of such. Bath Iron Works has had their total machine shop ventilation system, revamped with such a system with the self-cleaning option over ten years ago. The actual cost and size could be obtained the from Bath staff. The

results and return on investment have proven to come true. Smaller electrostatic precipitators are often specified for on board use and for engine rooms and machine shops.

As the demand for this technology has increased, a great many old problems of cleaning and size selection have been overcome. The basic motors and required horsepower has also been significantly reduced from the success of many installations. There are not off-the-shelf units available to each or many task-specific shipbuilding applications. Each type of application must be individually engineered and planned. The systems without self-cleaning features have a decrease in efficiencies with use. The cleaning of these systems is a task to be compared with exchanging of media falters.

There can be two distinct objectives in application of Electrostatic Precipitators:

1. To extract particles horn the weld fumes or other applications, and reflow the cleaned air to the work area.

2. The same as above, but to specifically reuse the cleaned air to reduce the cost of make up air, to be heated or cooled.

The Appendix contains more specifics on systems and Vendors who may be contacted for their data and engineering design aid.

2.3.2.2 MEDIA FILTER SYSTEMS

Manufacturers offer both systems, and they have specific application advantages and disadvantages. The chart below from Aercology gives a simple comparison.

Features	Filter-Type Smoke Collector	Precipitator	MediaFilter
CFM Range	500-1500	1300-5200	2000-6000
Suited for Ducted (source capture)	yes	yes	yes
Suited for Unducted (free hanging)	no	yes	yes
Suited for Dry Particulate	no	yes	FD models
Suited for Wet Particulate	no	yes	FD, FDV models
Automatic Cleaning Available	yes	yes (dry only)	no
Particulate Storage (loading) Capacity	high	low	medium
Sustained Efficiency with Usage	increases	decreases	increases
Available Voltage	220/440 VAC. 3-phase	220/440 VAC. 3-phase	220/440 VAC. 3-phase
Replacement Filters	yes (non-routine)	no	yes (routine)
Available in Portable Version	yes	yes	yes

2.3.2.3 AIR POWERED TRANSVECTORS

The usage and benefits of this technology to Shipbuilding has been available for some time, but limited to tank cleaning. The process is that of translating the energy from a common compressed air line flow through a well engineered device, the transvector can obtain an amplification of the airflow of from 12-20:1 to 2400 cfm ducted. These come various sizes for specific industrial applications. The principle of operation can be customized to many other applications, it becomes a matter of specific sizing.

The availability of clean compressed air, to most tasks in Shipbuilding and Repair makes for selected application of transvector type devices most attractive. The sizing and ease of use compared to large ducting systems, for ventilation gives much credence to the potential welding smoke application since they have small sized units with magnets, thus providing ease for source ventilation \extraction. This air flow could then be put to a falter stream, to clean and recirculate. **PLEASE AGAIN NOTE, NOT ONE PRODUCT BY ITSELF IS GOING TO SOLVE THE WHOLE PROBLEM. THE TOTAL SOLUTION WILL, IN EACH APPLICATION, COME FROM A COMBINATION OF COMPONENTS TO FORM A GOOD NEW VENTILATION\EXTRACTION SYSTEMS APPLICATION.** The Appendix section on Transvectors has some more technical and possible application data.

2.3.2.4 NEGATIVE PRESSURE UNITS

For many years the activities required for safe work environments have been pioneered by the Nuclear Industry. Now, fortunately the Shipbuilding Industry will, as a whole, look to its Nuclear functions as the source for improving the overall protection of its workers and the Shipbuilding workplace. The application of various required ventilation setups for the Nuclear side of shipbuilding utilizes some, highly advanced and efficient methods to clean and ventilate air streams.

The asbestos abatement equipment is the same, or similar to that which the Nuclear has required. This asbestos equipment must be utilized in Shipbuilding Industry for repair work on board older ships and the shipyard facilities themselves. The number of equipment manufactures for these type units have caused the equipment to come down in size and up in operating and cost performance.

In these two processes a common goal is self-containment and closed short loop systems or flows. These lead away from long costly runs of awkward, costly, inefficient 12" ducting. They go to the source, provide a safe clean environment, and avoid contamination to other treas. **WE NOW MUST LOOK TO APPLY THE SAME GOALS, THROUGH THE SHIPBUILDING INDUSTRY.**

The application and cost savings potentials are available.

2.3.2.3 INTEGRATED SYSTEMS

Improvements are available in many applications, and with many possible combinations of equipment and systems. The common denominator to success are the workers themselves. A team of Workers, Task Specific Ventilation Planning Function and Shipyard Management must be the first system to define and make to work as one.

SYSTEMS INTEGRATION:

- **It will require changes to current methods.**
- **It will often require more than one technology or piece of equipment to be utilized**
- **These integrated systems are to improve the overall working environment.**
- **Reducing smoke fumes**
- **Reducing the amount of large ducting**
- **Reducing the amount of supply air requirements**
- **Afford the operator ease and continuing use of set-ups.**

Some examples of specific possible systems will be briefly covered in the Specific Planning Sections of this report.

2.3.2.4 POINT SOURCE ARMS AND BOOMS

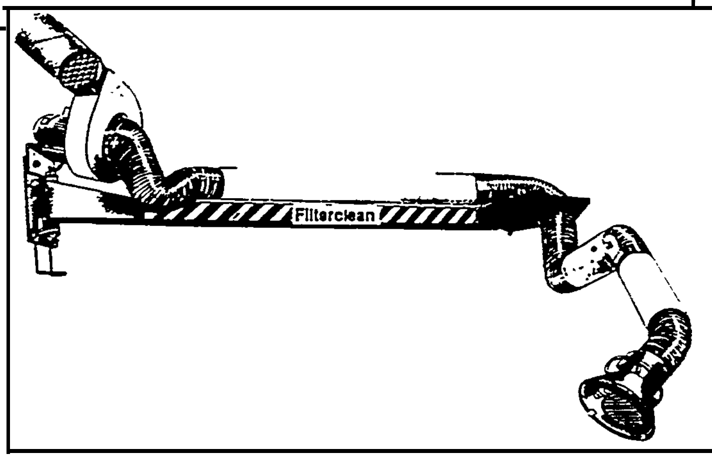
The ability to have the point source extraction equipment easily relocated by the worker, as they progress in welding has been a most difficult item.

Recently with the added attention to these problems in other industries, many improved arm and boom designs have come onto the market. The cost for these has also come down due to volume and competition.

Some of these are shown below:

Filterclean - THE SOURCE

ABA - AERIAL BOOM ARM



The NSW Aerial Boom Arm (ABA) **by Filterclean is the answer when ultimate work radius and flexibility is required. It is a pivoting wall column with an external adjustable ball bearing joint combined with our standard Industrial Ball Beanng Arms. The Aerial Boom can have an overall horizontal reach up to 26ft (when combined with our IBA-14 with a vertical work plane up to 26ft. Additionally the outer arm (IBA) can be positioned through a 360° work radius and the Inner arm through a 180° work radius. Filterclean's Aerial Boom Arm finally lets you position the capture hood to reach tight work areas.**

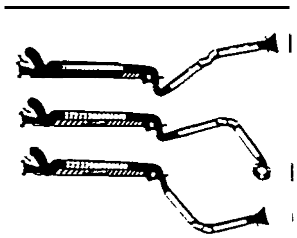
The fingertip positioning of the Aerial Boom Arm moves free and easy through ifs horizontal and vertical planes. Its external adjusting pivot and IBA elbow allow for fine tunning the movement to control the floating action of the arm. The ABA inner arm is capable of suspensing production equipment Up to 110 lbs This attractive feature keepS hoses and cables safely off the floor and thus improves the efficiancy of your operators and your overall work environment.

Special Features include:

-Tool Trolley with moving track(110 lbs on inner arm)
-External Ball Bearing Adjustment of wall pivot and IBA Elbow joints
-Extension Hose w/Magnetic Nozzle attachment-from 3 to 30ff.
-Hood Light
-Easy hood positioning
-Dampered Hood w/Rag Screen

Technical Data:

Pressure Loss Through the ACA.
ABA-16 = 2.29* w.g. @ 470 CFM and 3.49" w.g. @ 588 CFM
ABA-18 = 2.33 w.g. @ 470 CFM and 3.53" w.g. @ 588 CFM
ABA-21 = 2.37" w.g. @ 470 CFM and 3.61" w.g. @ 588 CFM
ABA-25 = 2.41" w.g. @ 470 CFM and 3.69" w.g. @ 588 CFM



Fllterclean Corp. P. O. Box 572, Chester, New Jersey 07930 (201) 879-4889, Fax.(201) 879-4217

The incorporation of arms and boom systems into the Shipbuilding Industry has been, increased in Europe and the Pacific. These items allow for continued utilization of the set up, and begin to optimize the investment. The degree of filtering and recycIing can vary with each installation, while the workplace as work progresses can be greatly improved.

The arms on the various demonstrations conducted at NASSCO, were the most highly rated improvement by the workers. Some arms are better than others, and some have added features such as lights which can be most helpful to the worker. Arms and boom systems will be basic to any shipyard as they progress with integrated systems for ventilation and extraction of fumes.

2.3.2.5 OTHER OPTIONS AND ACCESSORIES

Each application would have to be sized for arms, hoses, scoops, type of material, flameproof motors, lights, silencers and other items available.

These options are functional to the specific task and enhance the use and performance of the overall setup. The methods of control of issue must not be burdensome to the employees, if so they traditionally would do without. Again, not all applications or integrated systems should require the same set of equipment.

2.4 OPERATIONAL OVERVIEW

The Shipbuilding Industry does have quite a bit of common organizational and facility structures throughout. Most shipyards have the same names for their functions, even if they are private or public. Shipyards are also required to be located adjacent to water. The major differences between yards, are their overall size and local climates.

The size and climate drive the facilities and methods of ventilation deployed. Many shipyards must supply fresh air and heat many months of the year. Whereas shipyards on the west coast can do a great deal of their work outside. These factors, cause even a greater burden to ventilate extract one's welding fumes in the industry, since each yard does the same operations in various climatic conditions and does, or does not, enclose the same operations. The local and federal laws for the industry are thus vague in many areas.

This Operational Overview Section will discuss some of these differences. We will explore the basis work flows for shipbuilding. The shops, on unit on board and repair.

2.4.1 SHOPS

Each shipyard houses their shops machine, sheet metal. pipe, carpenter and weld school based upon the total yard space available and their climatic conditions. Those shops which house fume generating operations are usually set up to take advantage of prevailing, winds to aid naturally in the number of air exchanges which occur. The costs vary greatly in areas of the country where the air in these shops must be heated and/or cooled during extended Periods of the year. The cost of any heating or air-conditioning is a target for improvement. The level or current effectiveness of fume ventilation or extraction from shops has improved. Shops, on the whole, would be the easiest to gradually make improvements. This is due mainly that most of the fume generating workplaces are stationary compared to the rest of these operations throughout the shipyard.

2.4.2 ON UNIT/ON BLOCK

These will vary by shipyard based upon climate and size of yard as well as the material handling systems for units. Many shipyards have total or partial enclosure for their unit construction areas. The effective air exchanges natural to each structure due to its height and side wall configurations, coupled with climatic conditions, will determine the costs and methods for heating and/or cooling the facility. The many required fume generating operations are vented at a high cost and probably a poor

overall efficiency with the previously noted “sucker hoses” or blower fans with exhaust ducting to the outside. Very few facilities treat these exhausted fumes. These are basically diluted and released to the atmosphere, usually away from the intake or supply sources. These practices are subject to future regulatory change.

2.4.3 ON BOARD

On board is again, governed by climatic conditions and the effectiveness of scheduling of tasks at the on unit or on block level. The less done on unit the more costly to do on bead and the worst potential for confined workspaces and welding fumes. Thus more need and cost to ventilate/extract these ties. On board work conditions are degraded by climate and the need for ducting supply and exhaust air. Heating is done both with local heaters and air flows with additional ducting.

2.4.4 REPAIR

Repair work has limited welding as a general rule. But the need for task specific ventilation and danger from various tank cleaning tasks requires more care be taken to properly ventilate and control areas for access. As noted much of the new equipment and technology applies directly to such operations. Its use is quite low in the industry in total.

The removal of the danger from any fume at the source should be the rule. Yet, in shipbuilding, fumes are ducted through the ship and released to the atmosphere. This practice also could be effected by regulatory changes.

Repair most often requires that temporary ship ventilation systems be installed. These installations are costly and cause the overall workplace and work flow to be cluttered with ducting. Their operating performance is very restricted.

2.5 SPECIFIC PLANNING

The conclusions for this report clearly define to the Shipbuilding Industry the benefits to be gained from the immediate set up of a Task Specific Ventilation Planning Function. Some of the Requirement for this function could be:

- **Taking and maintaining a current equipment inventory.**
- **Equipment inspections and maintenance procedures.**
- **Supporting components definitions, inventory, purchasing, and warehousing. (Ducting, motors, tape, accessories, etc.)**
- **Employee training and handbooks.**
- **Current vendor communications and technical data.**
- **Weekly current deployment.**
- **Direct real time job charging of all tasks and equipment.**
- **Budgets to implement improvements**
- **Scheduling responsibility above those of the trades.**
- **Computer Equipment, Software, and Database access to properly develop and issue graphically Task Specific Planning.**
- **Long range planning to yard work load, quarterly.**
- **Engineering and Contracts interface.**

Each specific, ventilation/extraction application should be defined as to its current methods and equipment. Ventilation Planning Function, should document and define current, cost and frequency of use. Prioritize these and pursue through review with vendors and their current data the most effective long and short term solutions.

These should be costed, and reviewed for plannedintegration into the shipyard. The shipyard management could quarterly approved various levels and types of improvements from working with this staff function, as an operating requirement.

2.5.1 ENGINEERING INTERFACE

Traditionally Engineering designs for the Shipbuilding Industry, only try to document how the final ship is to be defined. This leaves many costly problem to the operations groups in Shipbuilding, since these drawings and basic, how to properly ventilate at various stages of construction are not planned for, documented in a cost effective manner nor supported by engineering design. The timing, cost and placement of ventilation and access holes are most often afterthoughts and require, internal costly change orders or down line processing to obtain.

These costs and the added operational costs are target areas for cost reductions within the industry. Concurrent engineering, and timely prerelease ventilation planning would allow for better systems at reduced costs to provide. This will also reduce change order activity, and allow for proper budgeting and planning in operations.

In our Shipbuilding and Repair Industry, the ships' ventilation systems are rarely utilized during construction and repair. This requires the costly deployments of temporary systems. With functional planning and concurrent design efforts these practices can be reviewed and integrated systems of temporary and the ships' systems could be developed and applied at a great savings in cost and workplace mobility.

2.5.2 CONTRACTS INTERFACE

The ventilation planning function should supply the contracts group with the costs associated for providing good ventilation to perform the contract. The Shipbuilding Industry must look to contracts to recover some of these costs of doing business. This will be more of an issue as regulation get tighter.

As progress is made with engineering, as to use of integrated on bored and temporary systems, contracts must be there to vigorously support these changes.

2.5.3 WORK BREAK DOWN PACKAGES

The lack of support and design in how to, in these packages has put a great burden on the operations side. Once there are ventilation plans they should be include within these packages. This would then require the proper planning for the support services groups, from the work packages and under the overall schedules. This would avoid the costly **REACTION** posture these support groups are traditionally forced into.

There has to be greater emphasis, on the proper how to build beginning with the setup of the workplace for ventilation/extraction of fumes. The Ventilation Planning

Function would drive the schedules. Thus only having trades go to work areas which are ready for them.

2.5.4 SHOPS

SHOPS WILL BENEFIT IN THE FOLLOWING WAYS:

- **Specific ventilation plans to fume generating equipment.**
- **Planned use of filtering and recycling airflow systems.**
- **Planned use of manifolds, with booms and arms to increase continuous source capture at the workplace.**
- **P1anned utilization of movable source capture equipment, with filtration and arms.**
- **Planned recirculation and filtration of secondary airflows, in the total work area.**
- **Reduced power consumption to operate equipment.**
- **Increased worker training and use of equipment.**

2.5.5 ASSEMBLY - FLOW LINES

THESE AREAS ARE AGAIN VARIABLE AS TO SIZE AND CLIMATIC CONDITIONS.

- **Integration of systems, for arms, booms, reduced ducting, filtration and recirculation.**
- **Planned use of manifolds, booms, and arms for source capture.**
- **Reduced power consumption to operate equipment.**
- **Use of filtration systems for all airflows and recirculation of cleaned air.**
- **Definitions of required and available accessories.**

2.5.6 ON UNIT/ON BLOCK

The specific application will require different sets of components be utilized. If the area is enclosed then more fixed facilitating of source capture and filtration systems can be implemented.

- **Integration of systems for arms, reduced ducting, filtration and recirculation.**
- **Specific layout and component requirements.**
- **Planned utilization of arms, accessories and booms.**
- **Application of negative pressure systems alone or integrated.**
- **Reduced power consumption to operate equipment.**
- **Planned increased level of source capture and filtration.**

2.5.7 ON BOARD/REPAIR

To plan to develop and use more integrated systems, to specific tasks to obtain overall increases in:

- **Reduced amount of exhaust ducting.**
- **Reduced requirement of supply air due to cleaning and recirculation.**
- **Potential use and integration of the ships' ventilation systems.**
- **Design and use of more portable self contained systems confine spaces, to extract and clean the air without ducting.**
- **Definition and use of required accessories, manifolds and arms for specific applications.**
- **Reduced power consumption to operate equipment.**

2.6 COST ANALYSIS

The costs associated with the methods, procedures and equipment in place today reflect a very costly way of doing business. This study, in its executive summary and conclusions has stated the deficiencies and poor level of performance with regard to the effectiveness of the current systems.

Attempts to confuse the issue of the recommended staff function for shipyard ventilation planning by numerous general cost analyses would continue the avoidance of the problem and action towards the recommended solutions.

SPECIFIC AREAS FOR COST IMPROVEMENTS:

- **Reduced deployment and cost of exhaust ducting.**
- **Reduced use and operating costs of high horse power motors used for exhaust and supply.**
- **Increased filtration and recirculation of cleaned air to the workplace.**
- **Increased use of non electric powered units to specific fume removal tasks.**
- **Concurrent Planning with design engineering and the ventilation planning function.**
- **Increased Utilization of Asbestos Abatement and Nuclear Environmental Control Technology and equipment.**
- **For specific recirculation costs analysis the following, format from one of the vendors quite thorough.**

Importance of Exhaust Air Management

It is often necessary to calculate energy savings **to** fully appreciate the benefits of an in-plant air cleaning system. Aside from the environmental impact of exhausting unfiltered air, consideration must be given to the direct energy cost associated with tempering exhaust replacement air. In most plant areas, general exhaust is sized to clear the area of contaminants generated by the manufacturing process. If a SMOG-HOG Air Cleaning System is installed to clear the air of these contaminants, the need for general exhaust rates can be drastically reduced. In no case, however, should exhaust and make-up air ventilation be completely eliminated. A minimum of 1/4 to 1/2 CFM of exhaust per square foot of floor area should be maintained to rid the area of odors and gaseous contaminants which may be generated by process or personnel.

If an area has a formal make-up air system, It is easy to see that a reduction in exhaust volume means a reduction in make-up air volume and resultant fuel bills due to heating less outside air. Even if there is no formal make-up air system. cost savings will still be achieved. These savings result by eliminating exhaust fans which create a negative pressure in an area. in turn causing cold outside air to infiltrate through doors, windows, vents, cracks, etc. This cold air places an additional burden on the building heating system. a burden that can be lessened by reducing the exhaust volume. The make-up volume reduction will always be equal to the exhaust volume reduction.

Energy Savings Calculations

In an effort to show the importance of energy savings and the positive effects a SMOG-HOG recirculating air cleaner can have, UAS developed two heat savings calculations for customer use. A manual calculation procedure is designed to give a quick approximation of energy dollars saved per year using readily available data A computerized calculation involves UAS computation and yields more complete and extensive energy savings data

Manual Method

The manual calculation orocedure relates to gross savings, and IS based on fuel cost, heating value. system efficiency and duty cycle of the exhaust volume of air saved. See this SectIon. page 2.

UAS Computerized Method

The computerized energy saving justification uses the gross savings and deducts the cost of electricity to operate the SMOG-HOG equipment, showing a net savings for the first year. Additional features of the computer printout are:

- accounts for anticipated increases in fuel cost
- calculates years to payback
- shows rate of return
- calculates net cash flow
- calculates net present value
- calculates depreciation expense

See this section, page 3.

Energy source	Heating Value	Units
COAL	18,000,000 to 28,000,000	BTU/TON
#2 FUEL OIL	139,400	BUT/GAL
#6 FUEL OIL	153,600	BTU/GAL
NATURAL GAS	980-1,050	BTU/CU. FT.
NATURAL GAS	100,000	BUT/CCF
NATURAL GAS	1,000,000	BTU/MCF
PROPANE (LP)	92,000	BTU/GAL
ELECTRICITY	3,415	BTU/KWH

100,000 BTU = 1 THERM

Heating Values of
Common Energy Sources

FIGURE 6-1

Type	% Efficiency
INDIRECT FIRED GAS/OIL	75-85%
DIRECT FIRED GAS	95%
HOT WATER OR STEAM	50-75%
ELECTRIC HEATING	95-I00%
COAL	70-85%

Typical System Efficiencies

FIGURE 6-2

SMOG-HOG®

Interior Air Cleaning Systems
Heat Savings Estimate Procedure

Date ____________________

CUSTOMER NAME ____________________

ADDRESS: ____________________

CITY ____________________ STATE: __________ ZIP: __________

INSTALLATION NAME ____________________

INSTALLATION ADDRESS: ____________________

CITY ____________________ STATE: __________ ZIP: __________

DATA SUMMARY

TERM	CODE	VALUE	UNITS
CURRENT EXHAUST VOLUME	A	________	CFM
PROPOSED EXHAUST VOLUME	B	________	
WINTER BUILDING TEMPERATURE	C	________	°F
AVERAGE HLD TEMPERATURE (See Design Weather Data Chart)	D	________	°F
OPERATING HOURS + 1 PER DAY	E	________	HRS/DAY
OPERATING DAYS PER WEEK	F	________	DAYS/WK
HEAT LOAD DAYS PER YEAR (See Design Weather Data Chart)	G	________	HLD/YR
HEATING FUEL TYPE		________	
COST PER FUEL UNIT	H	________	S UNIT
BTU PER FUEL UNIT (See Fig. 6-1)	J	________	BTU/UNIT
HEATING SYSTEM TYPE		________	
SYSTEM EFFICIENCY (- 100) (See Fig. 6-2)	K	________	% + 100

CALCULATION

0.154 x [A ________ - B ________]X[C ________ – D ________] x E ________ XF ________

x G ________ x H ________ ÷ J ________ ÷ K ________ = $ ________ SAVED/YR

UNITED AIR SPECIALISTS, INC.
4440 Creek Road • Cincinnati, Ohio 45242 USA

SMOG-HOG®

Interior Air Cleaning Systems
Computerized Energy Savings Justification

CUSTOMER NAME ______________________

ADDRESS: ______________________ PHONE: ( )

CITY ______________ STATE: ________ ZIP: ________

INSTALLATION NAME: ______________________

INSTALLATION ADDRESS: ______________________

CITY ______________ STATE ________ ZIP: ________

CURRENT EXHAUST VOLUME	________	CFM	SUMMER BUILDING TEMP	________	FDB
PROPOSED EXHAUST VOLUME	________	CFM	SUMMER BUILDING RELATIVE HUMIDITY	________	RH
WINTER BUILDING TEMP	________	F	SUMMER DRY BULB/WET BULB	________	°F
AVERAGE HLD TEMP	________	°F	COOLING HOURS	________	CH
HEAT LOAD DAYS	________	HLD			

TYPE OF FUEL TO BE SAVED (CHECK ONE):

( ) NATURAL GAS ________ $ PER THERM ( ) #2 FUEL OIL ________ $ PER GALLON

( ) ELECTRIC ________ $ PER KWH ( ) COAL ________ $ PER TON

( ) OTHER ________ $ PER —: UNIT)

TYPE OF HEATING SYSTEMS (CHECK ONE):

( ) FORCED AIR ( ) STEAM ( ) HOT WATER ( ) OTHER ________

PRESENT HEATING SYSTEM EFFICIENCY: ________ %

FACTORY OPERATION:

HRS. PER DAY ________ DAYS PER WEEK ________

SMOG-HOG EQUIPMENT

QTY. MODEL

________________________ COST OF EQUIPMENTS ________

________________________ EST.COST OF INSTALLATION $ ________

____

UAS
UNITED AIR SPECIALISTS, INC.
4440 Creek Road • Cincinnati, Ohio 45242 USA

Terms and Definitions

Present Exhaust Volume. The current exhaust air volume from the building, expressed in CFM (cubic feet per minute).

Proposed Exhaust Volume. The proposed exhaust air volume after SMOG-HOG system installation, expressed in CFM.

Heating System Efficiency. The efficiency of the present hearing system. This is used to account for additional energy which the present heating system consumes to produce desired comfort heat.

Electric Cost. The cost of electricity, expressed in $/KWH.

Operating Hours Per Day/Per Week. The number of hours per day/per week the SMOG-HOG system and the reduced exhaust are operational.

Fuel Cost Increases. The anticipated (or budgeted) fuel increases forecasted for a proposed facility or the fuel increases forecasted by utility companies.

SMOG-HOG System. The quantity and model numbers of SMOG-HOG equipment proposed, as well as the equipment operating mode. expressed as unducted system or ducted system at a specific external static pressure (ESP).

Saved Energy. The amount of energy saved, expressed in MBH or 1000 BTU's per hour.

Gross Savings. Total savings in fuel, expressed in dollars per year. Savings are based on fuel cost, heating value, system efficiency and duty cycle.

Electric Operating Cost. The cost of electricity to operate the SMOG-HOG equipment (motor horsepower and power packs).

Net Savings Ist Year. Net savings are the gross savings less the electric operating cost.

Years to Payback. Simple payback expressed in years, calculated as equipment plus installation cost divided by net savings per year. Fuel cost increases are included over the payback period.

Net Savings Additional Years. The net savings for additional years are the gross savings, escalated by fuel cost increases, less the electric operating cost. escalated by fuel cost increases.

Winter Conditions

Winter Building Temperature. The temperature of the air exhausted from a heated building during the winter, expressed in FDB.

Average OSA Temperature (AVG HLD Temp). The average outside air temperature during the heating season, found in Design Weather Data Chart for each state/city. expressed in FOB.

Heat Load Days (HLD). The number of days when the average outside temperature falls below 65°F., found in Design Weather Data Chart.

Summer Conditions

Summer Building Temperature. The temperature of the air being exhausted from an air conditioned building during the summer, expressed in °FDB.

Summer Dry Bulb/Wet Bulb. The summer design temperature during the cooling season, found in Design Weather Data Chart for each state/ city, expressed in °FDB/°FWB.

Cooling Hours. The average number of hours when cooling is required, found in Design Weather Data Chart.

Rate of Return

Depreciation Expense. The amount of the original purchase price of the equipment and installation to be expensed during any given year. The depreciation method used is the sum-of-the-years-digits method which writes off most of the equipment value in the early years.

Increased Pre-Tax Profit. The difference between utility savings and depreciation expense.

Increased After-Tax Profit. The increased pre-tax profit less tax.

After-Tax Profit & Depreciation. After-tax profit plus depreciation is used to calculate the net cash flow for each year of equipment operation. Depreciation is added to after-tax profit because depreciation is not a cash expense.

Net Cash Flow. The company's initial investment in equipment at the beginning of the first year listed as an outflow of cash and the total net savings provided each year by the equipment as the inflow of cash. Net cash flow for each operational year is equal to after-tax profit plus depreciation and utility savings less tax

Rate of Return. The after-tax annual rate of return on the company's investment.

Net Present Value. The amount the company could have paid in addition to its actual investment and still have obtained its required rate of return.

Design Weather Data Chart

State/City	Heat Load Days (below 65°F)	Avg. HLD Temp.	Avg. Yearly Temp.	Winter Design	Summer* Dry Bulb/ Wet Bulb	Cooling Hours	Alt.	AC Correction Factor
ALABAMA								
Birmingham	212	52.6	63	14	97/79	700	610	977
Mobile	151	55.2	68	21	95/80	1300	211	992
Montgomery	151	51.6	65	18	98/80	900	195	993
ALASKA								
Anchorage	365	35.0	35	–29	73/63	0	90	997
Fairbanks	365	25.7	26	–59	82/64	0	436	984
Juneau	365	40.3	40	–11	75/66	0	17	999
Nome	365	25.6	26	–37	66/58	0	13	1.000
ARIZONA								
Flagstaff	344	43.3	46	–10	84/61	1000	6973	771
Phoenix	151	55.6	70	25	108/77	1300	1117	959
Tucson	151	54.5	67	23	105/74	1300	2584	908
Yuma	151	59.7	72	32	111/79	1400	199	993
ARKANSAS								
Fort Smith	212	49.9	62	9	101/79	1200	449	983
Little Rock	212	49.8	62	13	99/80	1200	257	990
CALIFORNIA								
Eureka	365	52.2	52	27		100	217	992
Los Angeles	243	58.6	64	36	86/69	450	99	996
San Diego	212	50.1	62	38	86/71	450	19	999
San Francisco	365	56.9	57	32	83/65	100	8	1.000
COLORADO								
Denver	273	43.4	50	–9	92/65	350	5283	821
Grand Junction	243	42.4	53	–2	96/64	375	4849	834
Pueblo	243	43.2	53	–14	96/68	375	4639	841
CONNECTICUT								
Bridgeport	243	42.7	51	–1	90/77	300	7	1000
Hartfora	273	42,0	50	–4	90/77	300	15	1000
DELAWARE								
Wilmington	243	449	54	6	93/79	600	78	997
DIST OF COLUMBIA								
Washington	243	447	57	12	94/78	800	14	1000
FLORIDA								
Jacksonville	151	57.7	72	26	96/80	1600	24	999
Tampa	90	61.2	72	32	92/81	1650	19	929
GEORGIA								
Atlanta	212	50.9	62	14	95/78	750	1005	963
Macon	151	42.8	66	18	98/80	750	356	987
Savannan	151	53.5	67	21	96/81	750	52	998
IDAHO								
Boise	303	46.3	51	0	96/68	550	2842	899
Lewiston	273	45 6	52	1	98/67	550	1413	949
Pocatello	303	41 9	47	–12	94/65	550	4444	347

* 1% ASHRAE Design

State/City	Heat Load Days (below 65°F)	Avg. HLD Temp.	Avg. Yearly Temp.	Winter Design	Summer Dry Bulb/ Wet Bulb	Cooling Hours	Alt.	AC Correction Factor
ILLINOIS								
Cairo	243	47.7	59	4	97/80	400	398	.985
Chicago	273	41.7	50	−9	93/77	400	658	.976
Peoria	243	40.5	51	−8	94/78	400	652	.976
INDIANA								
Evansville	212	43.9	57	1	96/79	900	381	.986
Fort Wayne	273	42.5	50	−5	93/77	600	791	.971
Indianapolis	243	42.6	53	−5	93/78	800	793	.971
IOWA								
Burlington	243	40.3	51	−10	95/80	800	694	.975
Des Moines	273	41.0	50	−13	95/79	800	948	.965
Dubuque	273	38.8	47	−17	92178	800	1065	.961
Sioux City	273	40.1	49	−17	96/79	800	1095	.960
KANSAS								
Dodge City	243	44.9	55	−5	99/74	900	2594	908
Goodland	273	43.1	51	−10	99/71	900	3645	872
Topeka	243	44.2	55	−4	99/79	900	877	.968
Wichita	220	43.8	57	−1	102/77	900	1321	.952
KENTUCKY								
Covington	243	44.7	[illegible]	−3	93/77	900	869	.968
Lexington	243	46.2	55	0	94/78	900	979	.964
Louisville	243	46.5	57	1	96/79	900	474	.983
LOUISIANA								
Lake Charles	151	56.4	69	25	95/80	1500	14	1.000
New Orleans	151	56.8	69	29	93/81	1500	3	1.000
Shreveport	151	51.9	66	18	99/81	1450	252	.991
MAINE								
Caribou	365	38.8	39	−24	85/72	125	624	.977
Portland	303	40.5	46	−14	88/75	150	61	.998
MARYLAND								
Baltimore	243	45.9	55	8	94/79	700	146	994
MASSACHUSETTS								
Boston	273	44.7	50	−1	91/76	200	15	999
Worcester	273	40.3	47	−8	89/75	200	986	964
MICHIGAN								
Detroit	273	41.9	49	0	92/76	450	633	977
Flint	273	39.7	47	−7	89/76	475	766	972
Grand Ramas	273	40.5	49	−3	91/76	500	681	.975
Marquette	303	37.9	42	−14	88/73	400	677	.975
MINNESOTA								
Duluth	334	36.1	39	−25	85/73	200	1426	948
Minneapolis	273	35.5	45	−19	92/77	350	822	970
Rochester	273	35.4	44	−23	90/77	350	1297	953
MISSISSIPPI								
Jackson	151	51.4	66	17	98/79	1150	330	988
Meridian	182	53.2	65	15	97/80	1150	294	989
MISSOURI								
Kansas City	225	41.6	56	−2	100/79	900	742	973
St. Louis	223	43.5	56	−2	98/79	1000	535	980
Springfield	230	44.4	56	0	97/78	1000	1265	954

State/City	Heat Load Days (below 65°F)	Avg. HLD Temp.	Avg. Yearly Temp.	Winter Design	Summer Dry Bulb/ Wet Bulb	Cooling Hours	Alt.	AC Correction Factor
MONTANA								
Billings	303	41.4	47	-19	94/68	300	3567	.875
Glasgow	303	35.8	41	–33	96/69	275	2277	918
Great Falls	303	40.1	45	–29	91/64	275	3664	872
Havre	303	36.7	42	–32	91/66	275	2488	911
NEBRASKA								
Lincoln	243	44.9	53	-10	100/78	800	1150	958
Omaha	243	45.3	51	–12	97/79	800	978	964
Scottsbluff	272	46.8	49	–16	96/70	800	3950	863
Norfolk	255	41.5	49	–18	97/78	800	1532	944
NEVADA								
Las Vegas	181	51.7	66	18	108/72	1000	2162	.922
Reno	303	45.4	48	–2	95/64	500	4404	.848
Winnemucca	303	43.5	47	–8	97/64	500	4299	851
NEW HAMPSHIRE								
Concord	303	41 1	46	–17	91/75	200	339	987
NEW JERSEY								
Atlantic City	243	44.8	54	10	91/78	500	11	1000
Newark	243	44.8	54	6	94177	350	11	1000
Trenton	243	42.9	54	7	92/78	400	144	995
NEW MEXICO								
Albuquerque	212	43.2	56	6	96/66	420	5310	820
Roswell	212	47.9	59	5	101/71	680	3643	873
NEW YORK								
Buffalo	273	37.4	47	–3	88/75	150	705	974
New York City	243	43.9	54	6	91/77	350	16	999
Rochester	273	37.3	48	–5	91/75	350	543	980
Syracuse	273	41.0	48	–lo	90/76	350	424	984
NORTH CAROLINA								
Asheville	243	48.0	55	8	91/75	1000	2170	922
Charlotte	212	50.3	61	13	96/78	1050	735	973
Greensboro	212	475	58	9	94/77	1000	897	967
Wilmington	181	52.5	64	19	93/82	900	30	999
NORTH DAKOTA								
Bismarck	303	35.7	42	-31	9.5/74	300	1647	940
Williston	303	29.5	41	-28	94/71	300	1877	932
OHIO								
Cincinnati	243	45.7	54	2	34/78	700	761	972
Cleveland	273	43.0	50	–2	91/76	450	777	971
Columbus	243	42.1	52	–1	92/77	650	812	970
Toledo	273	42.1	50	–5	92/77	450	676	975
OKLAHOMA								
Oklahoma City	212	48.3	60	4	100/78	1050	1280	953
Tulsa	212	48.4	61	4	102/79	1050	650	976
OREGON								
Eugene	303	49.8	53	16	91/69	100	364	987
Medford	303	49.3	53	15	28/70	100	1298	953
Pendleton	273	46.4	52	–2	97/66	100	1492	946
Portland	303	49.8	52	17	89/69	100	21	399

State/City	Heat Load Days (below 65°F)	Avg. HLD Temp.	Avg. Yearly Temp.	Winter Design	Summer Dry Bulb/ Wet Bulb	Cooling Hours	Alt.	AC Correction Factor
PENNSYLVANIA								
Erie	303	41.9	47	1	88/76	400	732	.973
Philadelphia	243	45.3	55	7	93/78	400	7	1.000
Pittsburgh	273	43.8	53	−1	90/75	400	1137	.958
RHODE ISLAND								
Providence	273	43.4	51	o	89/76	250	55	998
SOUTH CAROLINA								
Charleston	212	54.3	66	19	94/81	750	41	999
Columbia	212	53.6	64	16	98/79	750	217	992
Greenville	212	50.6	61	14	95/77	750	957	.965
SOUTH DAKOTA								
Huron	273	36.0	45	−24	97/77	600	1282	953
Rapid City	303	38.4	47	−17	96/72	600	3165	888
Sioux Falls	273	36.8	46	−21	95/77	600	1420	948
TENNESSEE								
Knoxville	212	49.3	59	9	95/77	800	980	964
Memphis	212	50.6	62	11	98/80	1050	263	990
Nashville	212	56.7	60	6	97/79	950	577	979
TEXAS								
Amarillo	212	46.0	57	2	98/72	900	3607	874
Brownsville	90	62.1	74	32	94/80	1500	16	.999
Dallas	151	50.4	66	14	101/79	1400	481	979
El Paso	212	52.9	64	16	100/70	950	3918	864
Houston	151	56.7	68	24	96/80	1450	158	.994
UTAH								
Milford	273	42.0	49	−10	94/66	600	4966	830
Salt Lake City	273	43.9	52	−2	97/67	600	4220	854
VERMONT								
Burlington	273	36.6	45	−18	88/74	100	331	988
VIRGINIA								
Norfolk	212	49.0	60	18	94/79	900	26	999
Richmond	212	46.9	58	10	96/79	900	162	994
Roanoke	243	47.7	56	9	94/76	900	1174	957
WASHINGTON								
Seattle	365	51.1	51	17	82/67	200	14	1000
Spokane	303	42.9	48	−5	53/66	200	2357	916
Yakima	303	45.8	50	−1	34/69	200	1061	958
WEST VIRGINIA								
Charleston	243	46.8	54	1	92/76	500	939	965
Elklns	273	43.7	51	−4	87/74	475	1970	929
Parkersburg	243	45.7	55	2	53/77	500	615	977
WISCONSIN								
Green Bay	303	38.7	44	−16	88/75	350	683	975
La Crosse	273	38.2	46	−18	30/78	350	652	976
Madison	273	37.2	46	−13	92/77	350	858	9.33
Milwaukee	303	33.6	47	−11	30/77	350	672	975
WYOMING								
Casper	303	40.4	46	−20	32/63	300	5319	820
Cheyenne	303	41.4	45	−15	89/63	300	6126	792
Sheridan	303	40.0	45	−21	55/67	300	3942	863

2.7 *GOVERNMENT*

The Reagan Administration for eight years placed a virtual “Hold” on the activities of local and Federal agencies. The emphasis on workplace and environmental issues has changed greatly since the last Presidential elections. The problems and potential regulatory changes are still quite probable and would have very serious effects to all shipyards.

Each shipyard has a staff collecting, reporting and circulating specific information to their organizations. This report totally supports their efforts and should be given to them as another vehicle from management to be **PROACTIVE** towards regulatory activity.

3.0 APPENDIX

31 MANUFACTURERS OF EQUIPMENT

3.1 MANUFACTURERS OF EQUIPMENT

This is a partial listing of those manufacturers reviewed for this project. Most of the Plant Engineering and/or Facility periodicals, have an annual directory of manufacturers by category, these would be a larger reference base. We found that local manufacturers representatives were most cooperative.

1. **AERCOLOGY INC,** Old Saybrook, Connecticut 06425,203-399-7941
   ŽElectrostatic Precipitators, Filter and Media Filter Systems.
2. **NEDERMAN INC,** 6100 Hix Road Westland MI 48185,313-729-3344,
   •Fume Extractors
3. **UNITED AIR SPECIALISTS, INC.,** "Smog Hog", 440 Creek Road, Cincinnati Ohio 45242,
   • Industrial Air Cleaning Systems
4. **FILTER CLEAN,** P.O. Box 572, Chester, NJ 07930,201-879-4889
   Ž Source Capture Arms
   •Industrial Air C1eaning Systems
5. **AIR FLOW SYSTEMS, INC.,** P.O. Box *743366*, Dallas, TX *75374*
   •Industrial Air Cleaning Systems
   •Dust and Fume Exhaust Systems 214-272-3003
6. **CONVEY AIR,** P.O. Box 719002, Santee CA 92072,619-448-9484,
   •Air Particulate Separation Systems.
7. **TEPCO - TRION,** 101 McNeil Rd, P.O. Box 760, Sanford, NC 2731,919-775-2201
   •Air Cleaning Systems.
   •Only Approved Navy Source for on Board.
8. **WESTATES CARBON, INC.** 2139 Leo Ave., Los Angeles, CA 90040
   213-722-7500,
   •Activated Carbon Air Filters.
9. **NORTH FAB SYSTEMS, INC.,** P.O. Box 429, Thomasville, NC 27361,
   919-889-5599
   •Ventilation Clamp Systems
10. **BIOMARINE NC,** 45 Great Valley Parkway, Malverne, PA 19355215-647-7200,
    •Closed Circuit Breathing Apparatus.
11. **ELTON CORP,** 1941 Old Cuthbert Rd., Cherry Hill, NJ 08034609-936-1200,
    •Air Cleaning Systems.
12. **AMERICAN AIR FILTER,** P.O. Box 35690 Louisville, Kentucky 40232.
    Ž Industrial Air Cleaning Systems.

13. **RAM CENTRIFUGAL PRODUCTS, INC.,** 240 West 30th St., National City, CA92050, 619-474-7541, "Ram Fan 2000" Aqua Powered Blower.

14. **SEMCO AIR SYSTEMS -** P.O. Box 1797, Columbia Missouri 65205,314- 443-1481,- "Exclu-Sieve" Energy Recovery Systems.

15. **THURMOND-AIR QUALITY SYSTEMS,** P.O. Box 23037, Little Rock, Arkansas 72221,501-227-8888,
.Industrial Air Cleaning Systems

16. **COPPUS ENGINEERING,** CORP -344 Park Ave., Worcester, MA 01610- Blowers+.

17. **VORTEC CORP., 10125 Carver Road, Cincinnati, Ohio 45242, 513-891-7474,**
.Transvectors

18. **REGENCY ENVIROMASTER, INC.,** P.O. Box 3541, West Chester, PA 19382-215-344-0637- Asbestos Abatement & Nuclear Industries - "TorchCross" 3000 Negative Pressure Unit.

3.2 REFERENCES

3.2 REFERENCES

1. "INDUSTRIAL VENTILATION - 16th Edition" -A Manual of Recommended Practice, American Conference of Industrial Hygienists, Library of Congress # 62-12929, Edwards Bros. Inc., Ann Arbor, MI..

2. "VENTILATION STUDY - NASSCO 1979 ", Robert Turkington, Industrial Hygienist, Nassco.

3. "SHIP PRODUCTION", Richard Lee Storch, Colin P. Hammon, & Howard M. Bunch, Cornell Maritime Press, Centerville, Maryland 1988.

4. American Welding Society "WELDING FUME CONTROL WITH MECHANICAL VENTILATION" W. C. Rous, P.E., Firemans Fund Insurance Companies, San Francisco, CA. 1981.

3.3 MANUFACTURERS DATA

Control of Welding Smoke with Mechanical Ventilation

"The health hazard of welding smoke is established and the Federal Government has established the maximum permissible levels of welding smoke. The problem is to reduce eliminate or control welding smoke.

● There are two methods of controlling welding smoke, dilution ventilation, and local exhau source capture. Of the two methods, source capture is preferred because it eliminates th contaminant before it has passed through the breathing zone of the welder, and, if proper designed, installed and utilized, will virtually eliminate welding smoke in the shop or plant atmosphere.

'"Dilution ventilation is accomplished by the addition of uncontaminated air to redu the level of airborne contaminants which are of low toxicity. Dilution ventilation generally not as effective as source capture for controlling health hazards of contaminants.

> *"In some cases, dilution ventilation may be adequate to provide ventilation control Such uncommon cases occur where toxicity of the contaminant is low. The quantity generated is low, and the workers are far enough from the source.*
> *In general, dilution ventilation is seldom successful in removing or controlling welding fumes and dusts to a safe, acceptable level. " (emphasis added) . . .* [2]

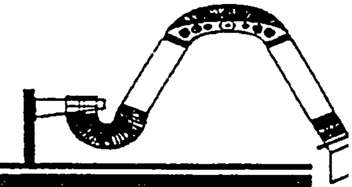
William C. Rous, PE
Environmental Sciences Unit
Loss Control Department Fireman's Fund Insurance Companies

00 Source capture systems capture the welding fume very close to the source, befc the fume has passed through the welder's breathing zone. Since the fume is captured at the source, the fume is totally eliminated from the atmosphere at tha point. The best a dilution system can accomplish is to reduce the amount of sm present in the atmosphere, it never eliminates it. As far as the welder is concerr the damage is done at the point where the smoke passes his respiratory zone. T the point of maximum exposure for him. Even if a general ventilation, or dilution system removes the smoke from the atmosphere after it passes his respiratory z (downstream of his nose), that system has done nothing to protect that welder.

> *"Because of its positive control characteristics, local exhaust is the most logical approach to the engineering control of contaminants. "* [3]

William **C.** Rous, PE

Filterclean Corp. P. O. Box 572, Chester, New Jersey 07930 (201) 879-4889 Fax. (201) 879-421



Filterclean TIPS

TOTAL IN-DOOR POLLUTION SOLUTIONS

Welding Smoke Hazards
SOURCE CAPTURE

The Human Factor, The Key to Successful Source Capture

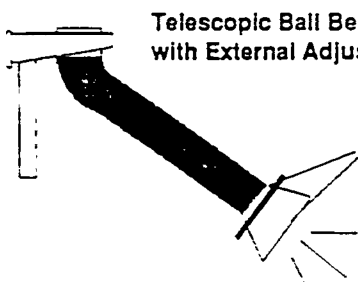
ŽSource capture systems are comprised of a capture hood or enclosure to capture the smoke, ductwork and a fan or blower. In addition, the system should also include an air cleaning system to avoid discharging contaminants to the atmosphere and to allow recirculation of interior air.

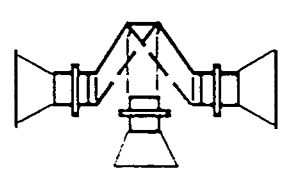
ŽSome source capture units utilize permanent fixtures such as backdraft tables, downdraft tables or enclosures. While these devices can be very effective, they require a lot of exhaust or filtered air and are of limited utility in many environments because of changing work requirements.

● In the majority of shop environments, the shape and size of pieces being welded are constantly changing, therefore the welding fume source capture system must offer the flexibility to adapt to the work being done.

● Most welding environments are well served by a system which combines portable source capture units and a system of installed fume collection arms. The portable units can combine capture and filtration in the same unit. The installed units can tie into a central exhaust or filtration system or can be a series of individual or paired filtration units.

•The human factor is a key to success in any welding fume collection system which requires operator involvement. If the welder has to position the welding smoke collection hood, system success dictates that the ergonomics of the system encourages continuing use of the hood by the welder. A fume arm that is difficult to position, drifts from its position, does not provide adequate suction, or is so bulky as to interfere with the welders work is doomed from the start. It will sit unused, or will require undue attention from management to enforce its use.





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The Human Factor... The Filterclean Connection

•The Filterclean portable RoII-Ex air cleaning unit and Filterclean Fume Arms solve the problem of involvement by the welder.

°°Fiiterclean Fume Arms "Capable Arms with a Delicate Touch" Filterclean Fume Arms are the industry leaders. They stay where the welder positions them, and they move with velvety smoothness made possible with ball and roller bearing movements at the base and knee joints. Whether the arm is an aerial crane arm with a full 26 foot coverage radius with 7 feet of vertica movement, or a compact 7 foot telescoping ball bearing arm, the Filterclea unit moves with unsurpassed one finger smoothness. Filterclean arms come with optional high intensity lights built into the capture hood which encourage the welder to use the arm as the light in the capture hood make it easier for him to see his work.

°°Filterclean Fume Arms are flexible enough for the tough applications. With five different arm configurations including Aerial Crane Arms, Aerial Boom Arms, Industrial Ball Bearing Arms, Telescopic Ball Bearing Arms and High Tech Fume Arms, Filterclean arms offer the most complete and versatile fume arms available to industry today. The Aerial Crane Arms and Aerial Boom Arms can span bays yet get into tough spaces. The industrial Ball Bearing Arm is the workhorse which comes in seven, ten, and fourteen foo lengths. The Telescopic Ball Bearing Arm actually telescopes from three t seven feet solving many tight space problems. The High Tech Fume Arm a three inch diameter arm for heliarc and precision work.

°°Filterclean RoII-Ex portable units offer the mobility to move to the job throughout the plant or shop.

Bibliography

1- Interview Dr. Ed Sein OSHA with Stephen Wood Vice President Air Cleaning Technology 4/15/89
2- AWS *Effects of Welding on* Health V
3- Rouse, William C., P.E. Weldlng *Fume Control With Mechanlcal Ventllation,* Fireman's Fund Insurance Companies 1980

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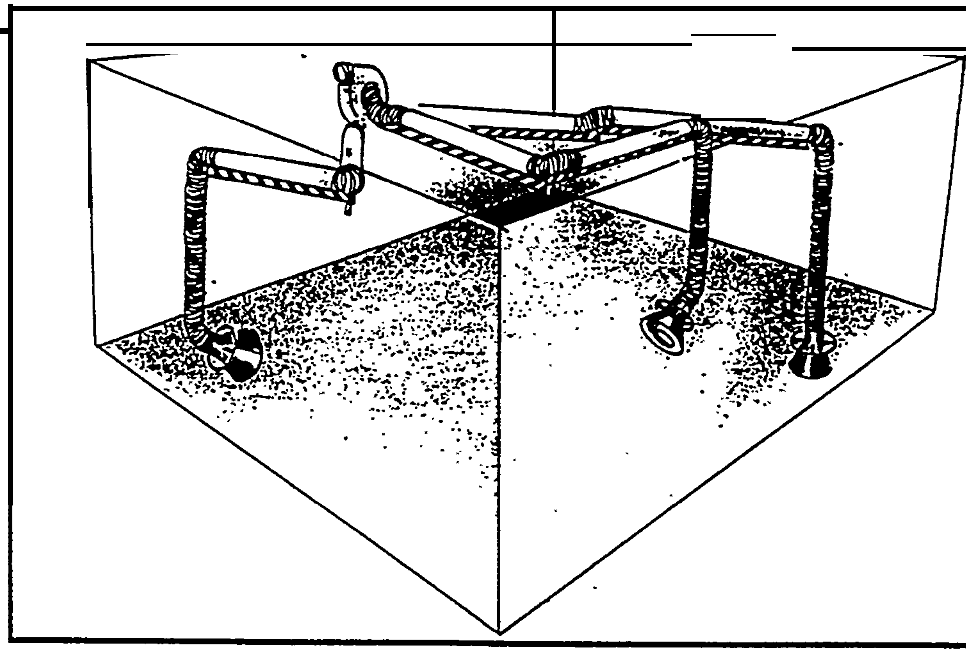
ACA - Aerial Crane Arm



The NEW Aerial Crane Arm (ACA) by Filterclean provides the flexibility and safety required in large Industrial manufacturing areas.

The movement of the Aerial Crane Arm is free and easy through its horizontal and vertical planes. its ball bearing extemal adjusting pivot and elbow joints, plus the telescoping 9ft vertfcal arm and tool trolley offer you a more efficiency and clutter free work environment while controlling potential hazards found in many industrial environments.

The Tool Trolley feature (standard) helps keep toots within reach of the operator. The inner arm and outer arm can be used to suspend heavy tools of varying weght. The inner arm is capable of suspending wire feeders and other production equipment up to 110 Ibs. The outer arm is capable of suspending light air tools and cables up to 20 lbs. This attractive feature keeps hoses and cables safely off the floor and thus improving the efficiency of your operator and the overall work environment.

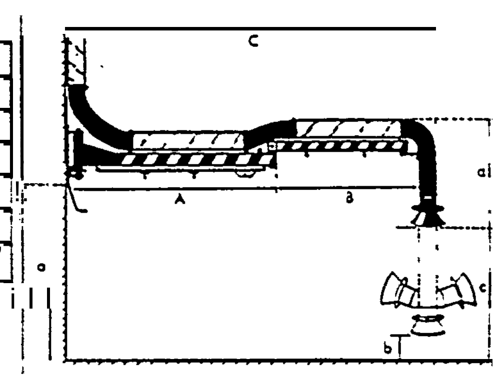
Special Features Include:

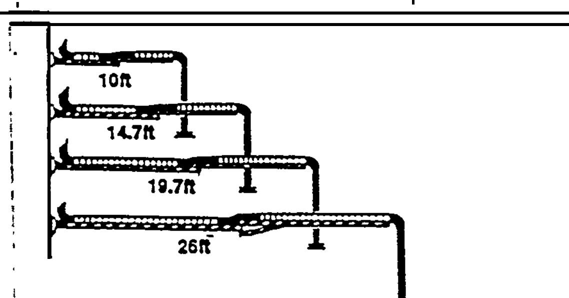
- -Tool Trolley with moving track (110 Ibs on inner arm, 20 tbs. on outer arm)
- -External Adjustment of pivot points (two)
- -180° pivoting wall bracket
- -6- Diameter System - Available in 20 & 26ft lengths
- -10“ Diameter system-Available in 10, 15 & 20ft lengths
- -Extension Hose w/Magnetic Nozzle attachment-up to 30ft.
- -Hood Light
- -Fingertip Mobility
- -Dampered Hood w/Rag Screen

Technical Data:

Pressure Loss Through the ACA:

Model No.	CFM	Inch W.G.	CFM	Inch W.G.	CFM	Inch W.G.
ACA-20-6	412	1.0”	588	2.1”	706	2.8”
ACA-26-6	412	1.04”	588	2.1”	706	2.9”
ACA-1 0-10	588	0.2”	882	0.5”	1471	1.6”
ACA-15-10	588	0.2”	882	0.5”	1471	1.65”
ACA-20-10	588	0.2”	882	0.5”	1471	1.7”

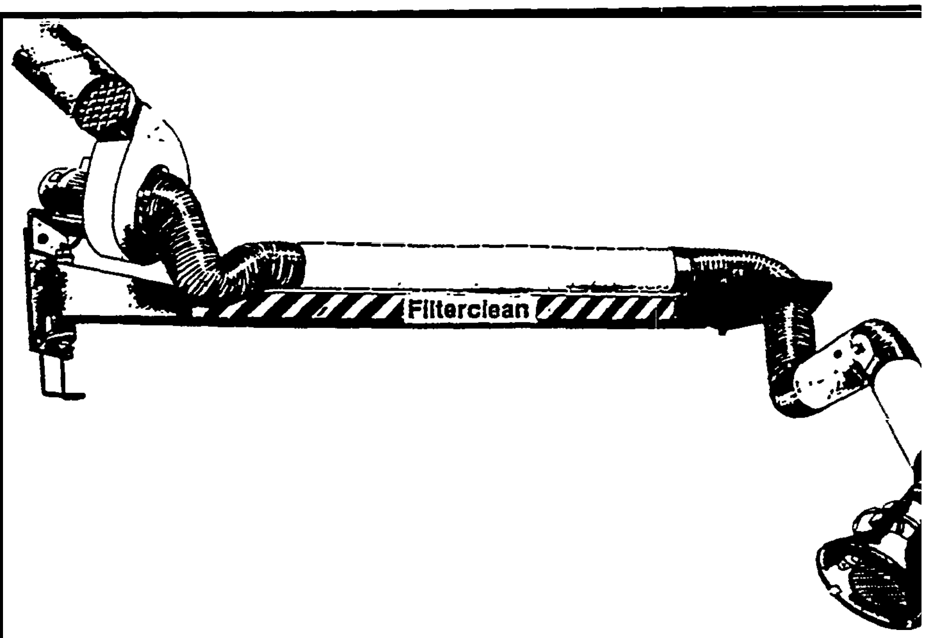




Filterclean Corp. P. O. Box 572, Chester, New Jersey 07930

AAIR PURIFICATION SYSTEMS
"Clean Air Specialists"
.250 Pierre Way
EL CAJON CA 92021

ABA - AERIAL BOOM ARM



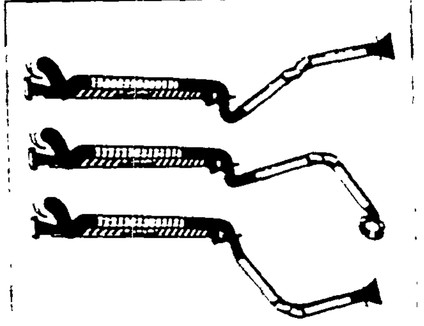
The NEW Aerial Boom Arm (ABA) by Fiiterclean is the answer when ultimate work radius and flexibility is required. it is a pivoting wall column with an external adjustable ball bearing joint combined with our standard Industrial Ball Bearing Arms. The Aeriai Boom can have an overall horizontal reach up to 28ft (when combined with our 16A-14) with a vertical work plane up to 26ft. Additionally the outer arm (IBA) can be positioned through a 360° work radius and the Inner arm through a 180° work radius. Filterclean's Aerial Boom Arm finally lets you position the capture hood to reach tight work areas.

The fingertip positioning of the Aerial Boom Arm moves free and easy through its horizontal and vertical planes. its external adjusting pivot and IBA elbow allow for fine tuning the movement to control the floating action of the arm. The ABA inner arm is capable of suspending production equipment up to 110 Ibs. This attractive feature keeps hoses and cables safely off the floor and thus improves the efficiency of your operators and your overall work environment.

Special Features Include:

-Tool Trolley with moving track(110 Ibs on inner arm)
-External Ball Bearing Adjustment of wall pivot and IBA Elbow
-Extension Hose w/Magnetic Nozzle attachment-from 3 to 30ft
-Hood Light
-Easy hood positioning
-Dampered Hood w/Rag Screen

Technical Data:



Pressure Loss Through the ACA:

ABA-16 = 2.29" w.g. @ 470 CFM and 3.49" w.g. @ 588 CFM
ABA-18 = 2.33" w.g. @ 470 CFM and 3.53" w.g. @ 588 CFM
ABA-21 = 2.37" w.g. @ 470 CFM and 3.61" w.g. @ 588 CFM
ABA-25 = 2.41" w.g. @ 470 CFM and 3.69" w.g. @ 588 CFM

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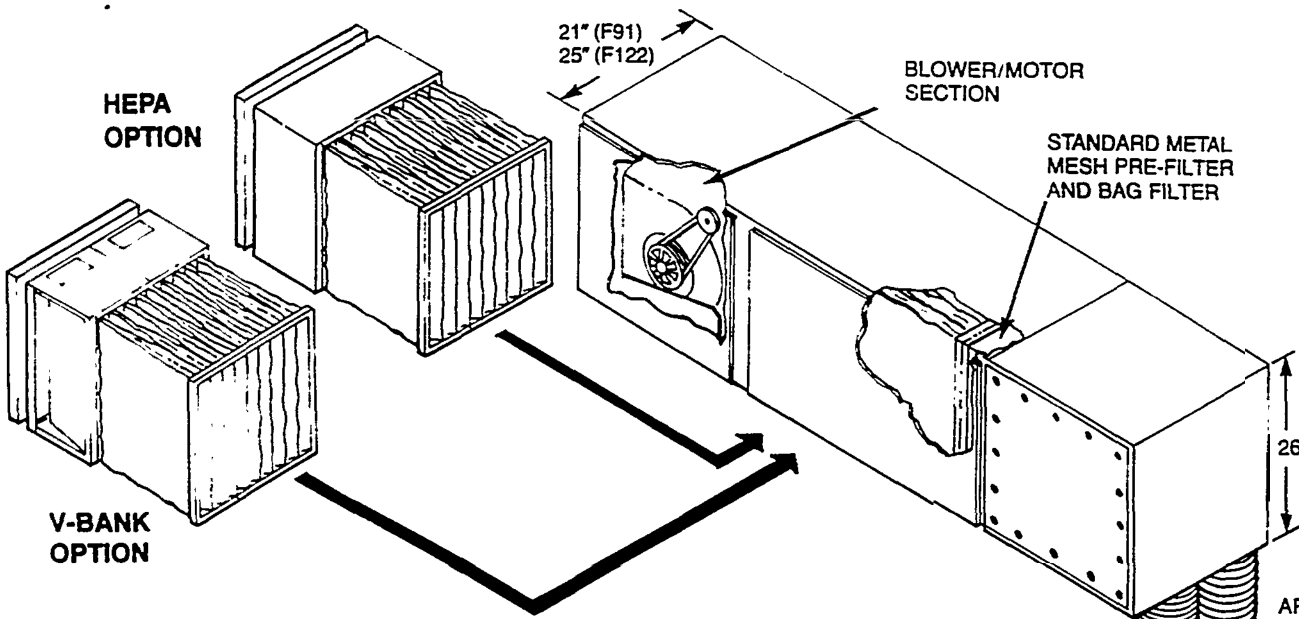
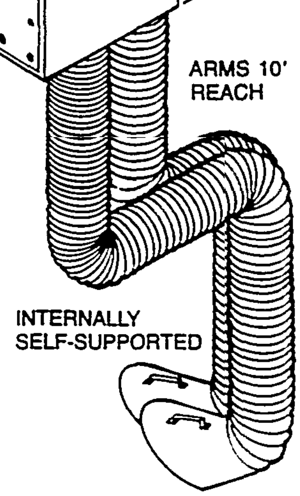




PRINCIPLES OF OPERATION

Air enters the aluminum hood at a rate of 1000 cubic feet per minute (standard configuration) picking up smoke, mists, dust, and other particulate 10-12″ from the hood and meeting OSHA STANDARDS. OSHA standard 1910.252(f)(3)(i) for ventilation requires 600 cfm for 10-12″ pickup range; Both models achieve this even with dirty filters. Optional 50 watt quartz hood light is available for improved workspace illumination. Pollutants are drawn through the 8″ diameter, internally self-supported pickup hose and into the cabinet plenum assembly. The plenum disperses the air over a larger area reducing the velocity. The pre-filter, main filter, and final filters (on models so equipped) remove the pollutants. The clean air then flows through the industrial blower and back into the workroom, or can be ducted outside.

SPECIFICATIONS

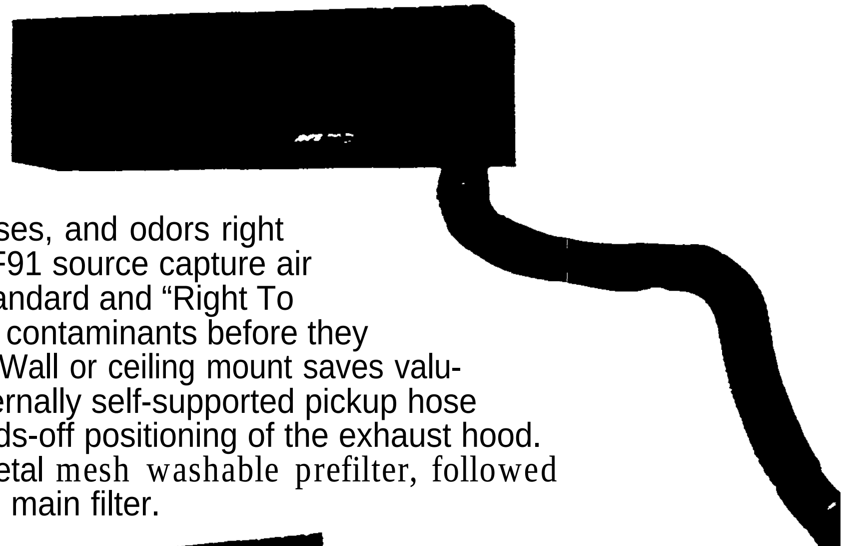
	F91	F122
DIMENSIONS	21wx26hx82L	25wx26hx88L
Weight	300 Lbs.	350 Lbs.
Cabinet	16 ga. welded zinc grip steel with 2 patt urethane coating	16 ga. welded zinc grip steel with 2 part urethane coating
Access	Hinged side door	Hinged side door
Airflow	1000 CFM standard	1000 CFM Per hose, standard
Pickup	Exceeds OSHAstandard 1910.252 (f)(3)(i) for ventilation, 10"-l2"pickup range at 600 CFM, with dirty filters	Exceeds OSHAstandard11910.252 (f)(3)(i) for ventilation, 10"-12"pickup range at 600 CFM, with dirty filters
Noise	80 dBa at 5'	80dBaat5'
Electrical	1 ½ HP TEFC motor, 230/460/3/60	2 HP TEFC motor, 230/460/3/60
Filters	2" metal mesh prefilter, 68% arrestance followed by 95% (ASHRAE52-76) main filter, 96 sq. ft. area	2" metal mesh prefilter, 68% arrestance followed by 95% (ASH RAE 52-76) main filter, 120 sq. ft. area

Airflow Systems, Inc.
P O Box 743366 Dallas Tx 75374 (214) 272-3003

Airflow Systems, Inc.

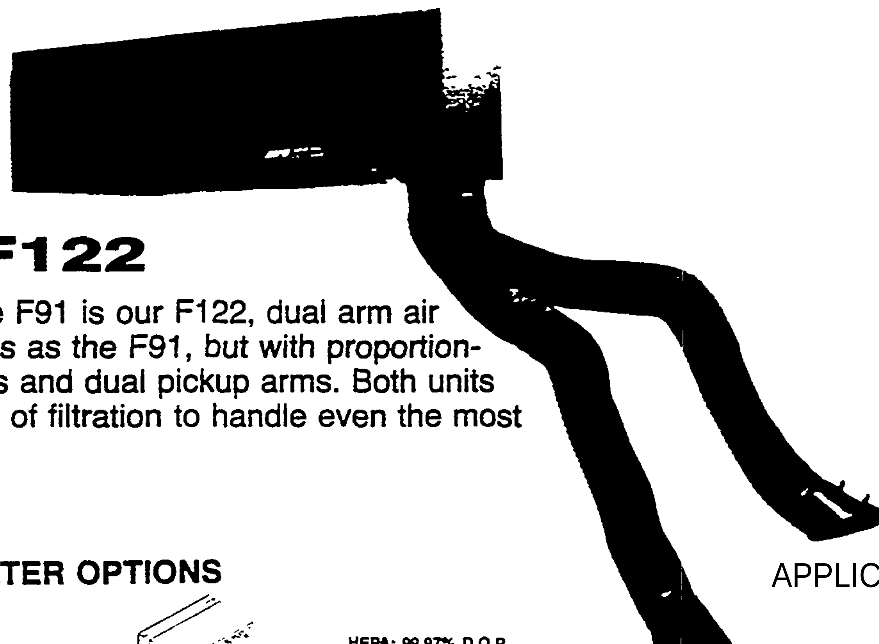
SOURC CAPTUI

INDUSTRIAL AIR FILTEI
NON-ELECTROSTAT



MODEL F91

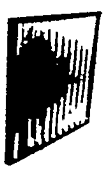
Capture smoke, dust, mist, gases, and odors right at the source with the Model F91 source capture air cleaner. Helps meet OSHA standard and "Right To Know" standards by removing contaminants before they each workers' breathing zone. Wall or ceiling mount saves valuable floor space, while the internally self-supported pickup hose stays where you put it for hands-off positioning of the exhaust hood. Standard filtration inciudes 2 metal mesh washable prefilter, followed by 95% heavy duty disposable main filter.



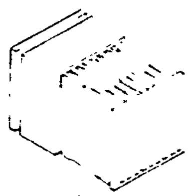
MODEL F122

A larger version of the F91 is our F122, dual arm air cleaner. Same features as the F91, but with proportionally larger components and dual pickup arms. Both units feature up to 4 stages of filtration to handle even the most difficult applications.

FILTER OPTIONS

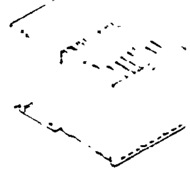


OIL MIST SEPARATOR:
Includes self-cleaning louver pre-filter followed by a 2" mesh filter for oil mist applications.



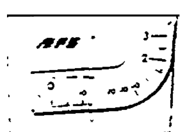
HEPA: 99.97% D.O.P.
HEPA filter preceeded by 95% bag filter for ultra high efficiency application.

4" PRE-FILTER:
30% efficient pleated prefilter, replaces 2" mesh. For heavy smoke and dust applications where a disposable prefilter is preferred.



GAS ADSORPTION:
2 V-Bank adsorber modules preceeded by 95% bag filter for gas adsorption. 40 Lb. (F91); 50 Lb. (F122).

EASY-CLEAN
Polyester membrane cleanable bag filter. 95% arrestance. Takes place of main filter.

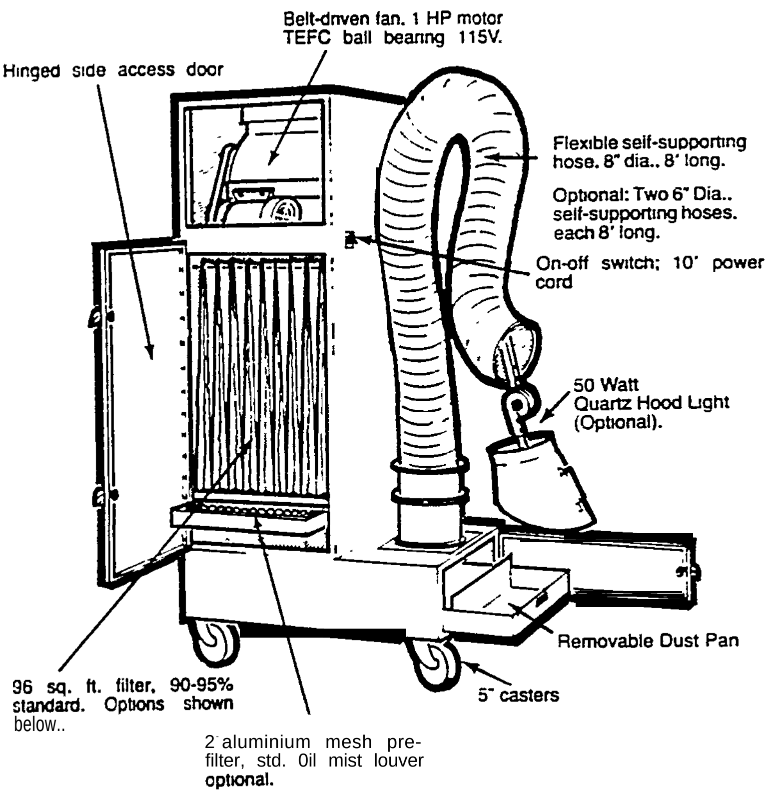


PRESSURE GAUGE KIT:
Indicates when to change filters. Includes 0-3" gauge. Factory mounted on unit.

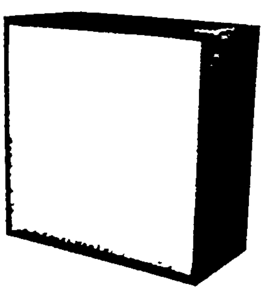
APPLICATIOI

- WELDING SMOK
- OIL MIST
- SOLDERING SM
- CUTTING SMOKI
- SANDING DUST
- GRINDING DUST
- FUMES
- SOLVENTS
- FIBERS

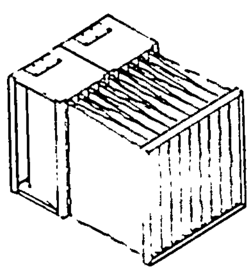
PAC 90
PORTABLE AIR CLEANER



FILTER OPTIONS



HEPA FILTER option — includes 95% DOP HEPA filter and short 36 ft² bag filter, 95%. 99.97% DOP HEPA also available.



ADSORPTION Option — includes 2 V-bank modules and short 36 ft² bag filter, 95%. Holds 40 lb. carbon or 60 lb. KM_nO_4. Modules are refillable.

SPECIFICATIONS

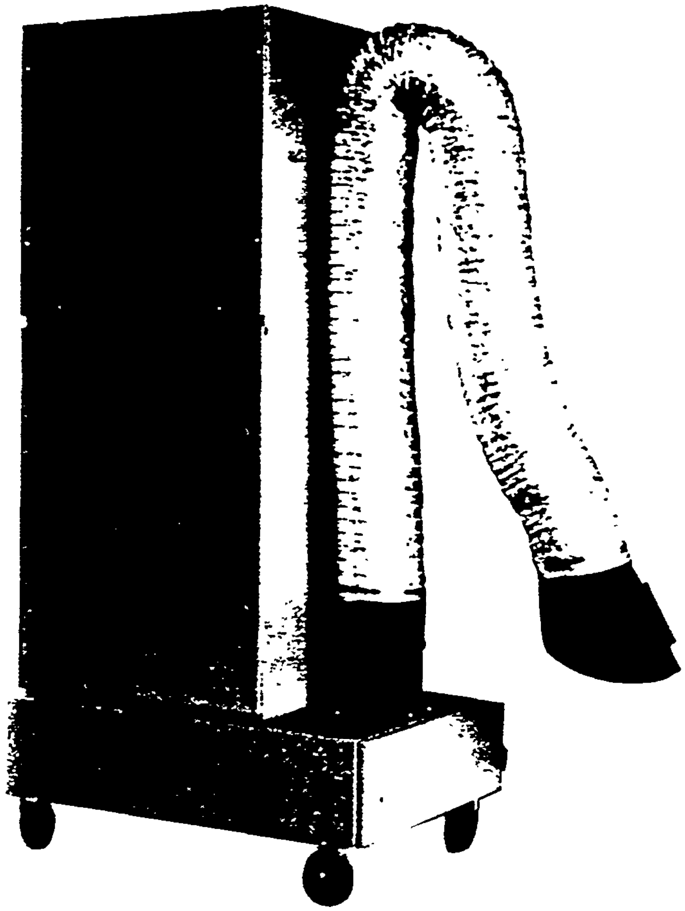
DIMENSIONS:	35"L x 26"W X 76"H
CONSTRUCTION:	16 ga. welded steel cabinet with side access doors, dust pan door, 5" casters and self-supporting pickup arm
WEIGHT:	310 lbs./35O lbs.
FILTER ACCESS:	Hinged side access door
AIRFLOW:	1000 CFM in standard configuration
ELECTRICAL:	1 HP TEFC ball bearing motor, 3450 RPM, 115/1/60, 12.0 amps typ. Includes on-off switch and 10' power cord. 3-phase motor optional.
BLOWER:	10x 10 forward curved, belt drive with ¾ shaft, sealed ball bearings, and adjustable speed pulleys
NOISE LEVEL:	68 dBA @ 3 ft.
PICKUP VELOCITY:	2200 FPM
PREFILTERS:	2" aluminium mesh, std. 011 mist louver, optional
MAIN FILTERS:	96 @ bag, 90-95% std.
OPTIONS:	96 ft² bag, 55-60% easy clean bag Bag and gas adsorber Bag and HEPA filter 50 W. light in hood
DUAL ARMS:	Two 6" Dia., self-supporting pickup arms, 8' long.

Airflow Systems, Inc.
P.O. Box 743366, Dallas, Tx. 75374 (214) 272-3003

Airflow Systems, Inc.

PAC 9

PORTABLE AIR CLEANE
FILTER TYPE



SINGLE ARM UNIT

- *Capture Pollutants at th*
- *Protect Workers Breathi*
- *Portable — Moves from Place*
- *Filters Out Smoke, Dust, &*

Capture welding smoke, oil m odors, and gases right at the sourc PAC 90 portable air cleaner. The porting, flexible pickup hose can positioned in all three axes, allo plete capture to help comply w breathing zone regulations.

PAC 90 uses ordinary 115V outl special wiring or hook-ups are req narrow, 26 width allows the PAC right through standard size doorwa roll it right up to the pollutant and the problem on-the-spot.

FEATURES	BENEFITS
Non-Electrostatic	Low Maintenance
Source Capture	Comply with OSHA
Portable	Versatile
High Efficiency, 95%+	Clean Air
Side Load Door	Easy Access
115V with Cord	Use Anywhere
Industrial Duty	Durable
High Volume (CFM)	Quick Pick-Up
Self-Contained	No Installation
Optional HEPA Filter	Handles Toxics
Optional Adsorption	Gas/Odor Control

APPLICATIONS

Welding Smoke	Toxic Dust
Oil Mist	Lint
Carbon Dust	Fibers
Plastic Smoke	Solvents
Grinding Dust	Fumes
Sanding Dust	

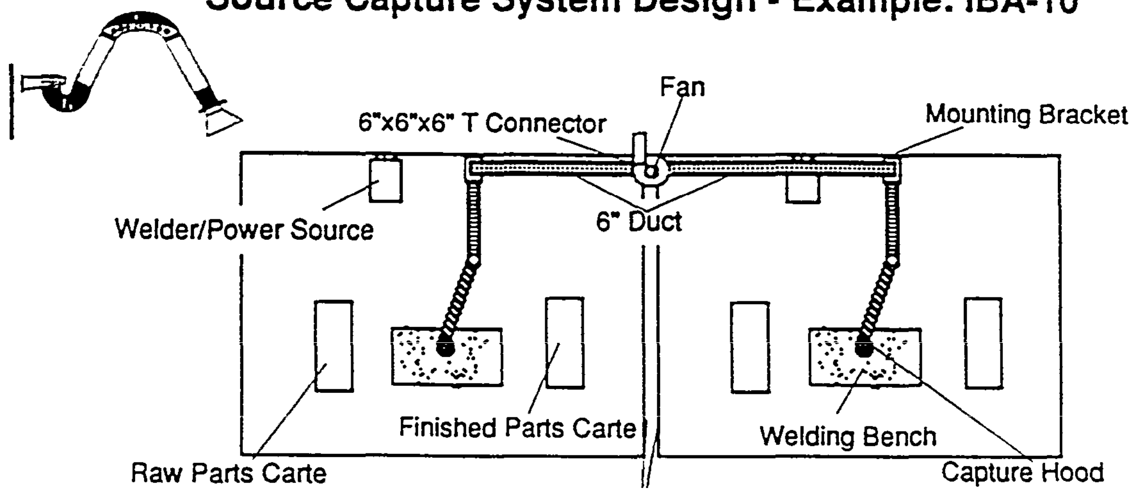
DUAL AR

Filterclean TIPS

TOTAL IN-DOOR POLLUTION SOLUTIONS

Source Arm SYSTEM DESIGN

Source Capture System Design - Example: IBA-10



Welding Shield Protectors

The system shown here represents a double arm system, commonly required in a welding area. The design criteria utilizes the same steps whether the system requires two arms or five arms.

Parameters:

- 10ft x 14ft work areas separated by a welding curtain.
- The welder works with his back to the wall and some 7 ft off the outside wall
- The welder takes parts from the raw parts carte, welds each part and then places the welded part on the finished parts carte to be moved to another position in the facility.
- Each drop will be designed for 600 CFM

For this example we are utilizing the Filterclean IBA-10 Source Capture Arm.

Design Procedure:

1: Make a simple sketch of your installation.
2:@ 600 CFM the IBA-10 will produce 1.8″ w.g. Pressure.
3: Determine the total length of duct from the fan to the farthest arm.
4: Multiply duct length by .006″ w.g. to get the main duct pressure loss.
5: Add the number of elbows (1.5 diameter turn) from the fan to the farthest arm by 18″ w.g.
6: Add the pressure from the arm to the main duct and elbow losses = Total System Pressure Loss.
7: Count the number of arms needed from the system and multiply by 600 CFM = Total System CFM
8: Start at the farthest arm from the fan and follow the duct diameter chart listed below:

0-600 CFM	6″ Diameter		
601-1000 CFM	8″ Diameter	3201-4200 CFM	16″ Diameter
1001-1600 CFM	10″ Diameter	4201-5200 CFM	18″ Diameter
1601-2300 CFM	12″ Diameter	5201-7000 CFM	20″ Diameter
2301-3200 CFM	14″ Diameter	7001-8000 CFM	22″ Diameter

9: Make all connections to IBA's with 6.25″ Duct
10: Select the proper tan regarding total system requirements

Example on System Shown CFM per IBA-1 O Arm =	600 CFM
Arm Pressure Loss =	1.80″ w.g.
Main Duct = 15ft to the farthest arm= 15 x's .006 =	.09″ w.g.
Number of Elbows= 2 x's .18″ w.g. =	.36 w.g.

Total System Requirements = 1200 CFM @ 2.25" w.g.

Filterclean Corp. P. O. Box 572, Chester, New Jersey 07930 (201) 879-4889 Fax. (201) 879-4217

ELTRON®

ELTRON AIR CLEANERS COST LESS TO OPERATE!

CLEANED AIR IS ENERGY $AVED!

CLEAN AND RECYCLE PLANT AIR TO:

- Reduce heating and cooling costs
- Improve working conditions
- Overcome negative pressure problems and drafts
- Boost worker and machine productivity
- Reduce cleanup and maintenance expenses
- Comply with OSHA and EPA regulations

Eltron's experience assures quality, reliability and value

Over 15 years of air engineering experience stands behind every product. Each has evolved through continuous upgrading to repre the very best in air cleaning technology.

Eltron customers receive outstanding technical support, superior equipment design, premium materials and the highest quality of workmanship for unsurpassed performance and lasting reliability

You're invited to take advantage of Eltron's technical expertise b calling to discuss any air cleaning or ventilation engineering probl Copies of our acclaimed Application Reports and Engineering Da Sheets are available to anyone who wants to learn about the late state-of-the-art in industrial air cleaning and ventilation engineeri technology.

Eltron's low voltage electrostatic collectors include: **Plant** and **Process** type industrial **Precipitators.** Smokatron **Tobacco Smoke Collectors. Wet Precipitators, Condensing-Precipitator Systems,** Dustbuster and Smogbuster **Automotive Shop Cleaners,** and **Electrostatic** Scrubbers.

All excel at collection of extremely small particles and visible emissions, including wet, drv or sticky materials. Multiple-pass units can incorporate filter and/or sorption components. Even vapors can be collected bv **Wet Precipitators,**

Electrostatic Fume Stop'ers™, and **Electrostatic Scrubbers.** Extended Pe and Conductive Precipitate™ Style extra dependability with the lowest maintenance requirement.

STATE-OF-THE-ART ELECTROSTATIC AIR CLEANING TECHNOLOGY

MOBILE AIR CLEANERS

UNDUCTED AIR CLEANING

PLANT PRECIPITATORS

PROCESS PRECIPITATORS

WET PRECIPITATORS — **ELECTROSTATIC SCRUBBERS**

CONDENSING-PRECIPITATOR SYSTEMS

FILTER COLLECTORS

SELF-CLEANING PRECIPITATORS — **ULTRASONIC CLEANERS/STRIPPING CE**

VAPOR SORPTION COLLECTORS — **MECHANICAL COLLECTORS**

FUME EXTRACTORS, HOODS, FLEX DUCT, DUCT CLA...

SCHOOL & LAB VENTILATION — **AUTOMOTIVE SHOP CLEANER**

TOBACCO SMOKE COLLECTORS — **COMPUTER & CONTROL ROOM AIR C**

Low Maintenance Air Cleaners

it you re tired of replacing filters...

...consider Vibrotron "self-cleaning electrostatic dust collectors (see Self-Cleaning Precipitators) or one of Eltrons many shaker and pulse-cleaned automatic dust collectors see Filter Collectors). Fluid contaminants dram continually from self-cleaning Plant Precipitators and Process Precipitators. Self-cleaning Wet Precipitators can automare most collector maintenance when the pollutants to be handled are hvgroscoplc. sticky, semi-solid or soluble.

If vou don t want to clean electrostatic collectors so often...

...specify Eltrons Extended Performance "or Conductive Precipitate" style construction and enjoy collectors winch are built to eliminate the cause of most routine maustral precipitator maintenance. These unique models can greatly extend your oil mist and smoke conectors useful operating lifetime between cleaning cycles (see State-of-the-Art Electrostatic Air Cleaning Technology).

Find out how Eltron can clear the air at your plant

OK Eltron, how would vou solve this one?

- ☐ Please make a recommendation for my air cleaning problem
- ☐ Help! Have an engineering representative call for an appointment

MY PRIMARY CONCERN IS
- ☐ Interior air cleaning
- ☐ Tobacco smoke elimination
- ☐ Exhaust pollution control
- ☐ Energy conservation
- ☐ OSHA-EPA regulations
- ☐ Other: ____________

I M THINKING IN TERMS OF
- ☐ Ducted source-capture ventilation air cleaning
- ☐ Unducted (general ventilation) air cleaning
- ☐ I want your recommendation first

CONTAMINANTS TO BE COLLECTED
- ☐ Dust
- ☐ Tobacco smoke
- ☐ Coolant mist and fog
- ☐ Welding smoke
- ☐ Oil smoke
- ☐ Gases and vapors
- ☐ Other: ____________

POLLUTANT SOURCE IS ____________

WE NEED THIS INFORMATION
- ☐ Immediately
- ☐ Possible action within 1 year
- ☐ Reference—for file only

PRODUCT INTERE
- ☐ Mobile air clean
- ☐ Plant Precipitato
- ☐ Process Precipit.
- ☐ Wet Precipitator
- ☐ Electrostatic scr
- ☐ Condensing-Pre hot smoke
- ☐ Disposable Med
- ☐ Self-Cleaning Fil
- ☐ Pulse-cleaned C
- ☐ Self-cleaning pre
- ☐ Fume Stop er & vapor collectors
- ☐ Cyclones & Mec
- ☐ Swing arm Fume
- ☐ Tobacco Smoke
- ☐ Ultrasonic parts
- ☐ School & Lab ve
- ☐ Dustbuster & Sn for auto repair sl
- ☐ Computer room
- ☐ Cleaning & strip

WE'D LIKE SPECIFI

Name: ____________ Title ____________

Company ____________

Division ____________ Phone: ____________

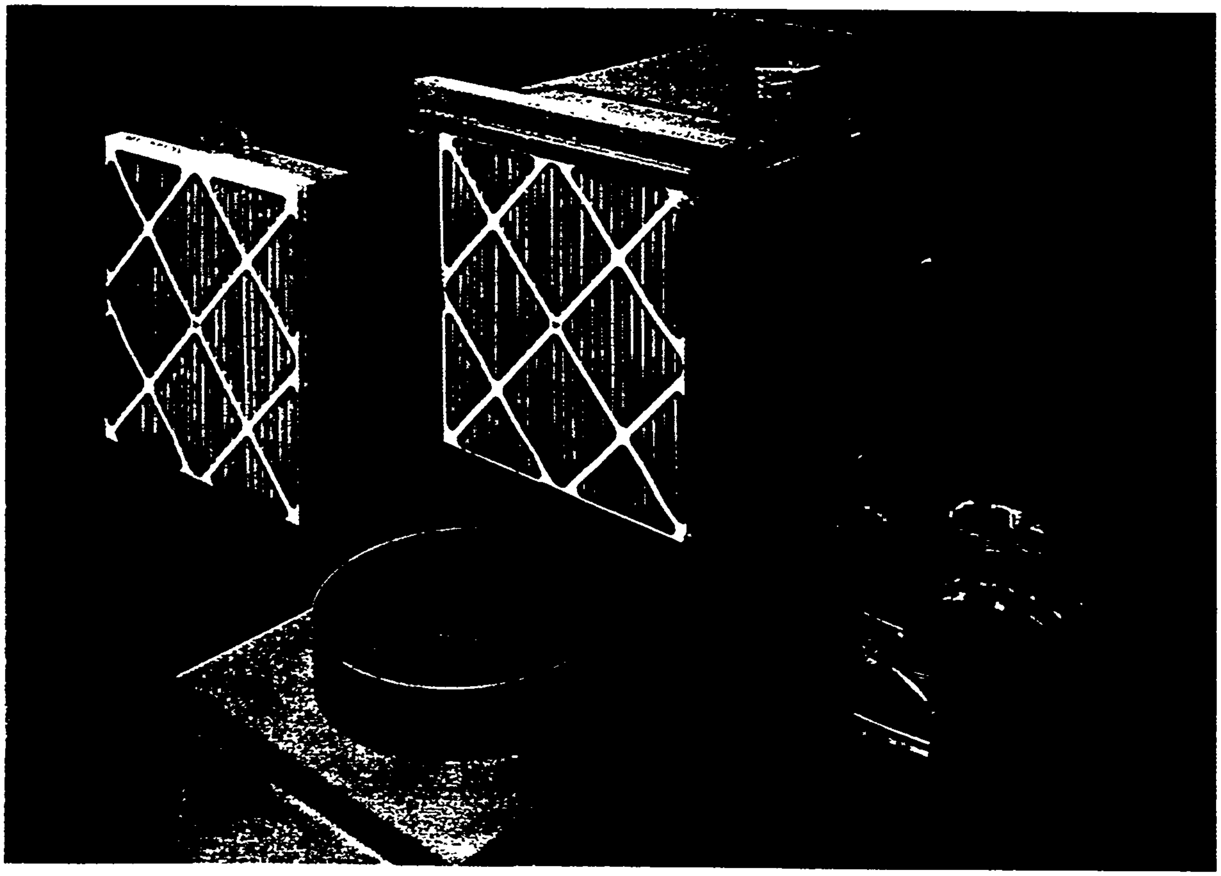
Address ____________

City State, Zip ____________

TORCHCROSS

EQUIPMENT FOR THE ASBESTOS ABATEMENT & NUCLEAR INDUSTRIES

3000 NEGATIVE PRESSURE UNIT



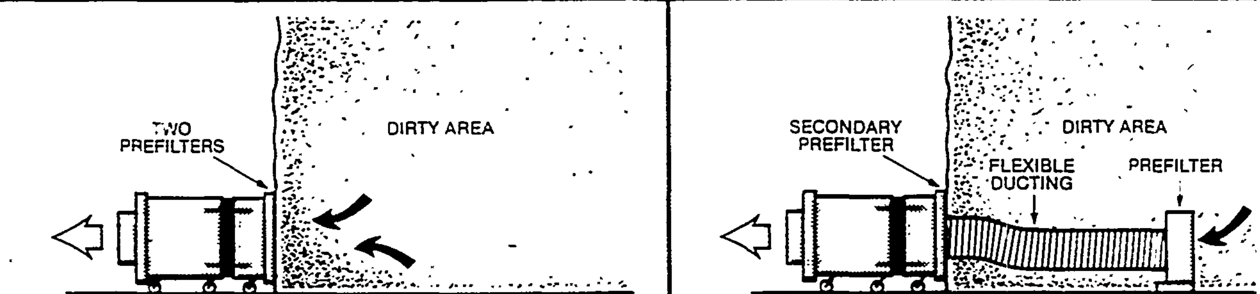
- Capacity for containment areas up to 45,000 cu. ft.
- Two powerful 1.3 h.p. blowers.
- Damper adjustment for lower air volumes.
- Rugged fully welded construction to withstand tough site conditions.
- Standard 20 amp, 115V, power requirements.
- Compact dimensions.
- Unique failsafe Hepa filter location.
- Optional remote prefilter housing for maximum flexibility.

CHECK OUT THE FEATURES WHICH MAKE TORCHCROSS YOUR BEST E

A recently opened manufacturing facility situated in Hagerstown, Maryland houses the very latest co controlled production machinery in a 36,000 sq. ft. factory. Quality of build is assured and production t minimised to give our customers quick deliveries and the most economical prices.

- **AVOIDS THE NEED FOR DECONTAMINATION** Versatile design means that the unit need never be placed in the containment area.
- **ADJUSTS TO PRECISE VOLUMES** with the simple control damper.
- **INDIVIDUAL BLOWER SWITCHING** to allow use on smaller contracts or to provide standby capacity.
- **EASY TO HANDLE** 38″ long x 32″ high x 28″ wide.
- NO SHUT DOWN TO CHANGE PREFILTERS Prefilters are retained by four finger catches are accessed from inside the containment a
- COMPREHENSIVE CONTROLS incorporate manometer, high/low pressure warning, timer, hours run counter.
- QUICK CONNECTION TO CONTAINMENT via large connecting face.
- BLOWER POWER EXTENDS FILTER LIFE **With over 3″ wc available, maximum filter li ensured.**

EASY INSTALLATION AND OPERATION MAXIMISES SAFETY - MINIMISES COS



WHEEL UNIT DIRECTLY UP TO OUTSIDE OF ENCLOSURE

OR

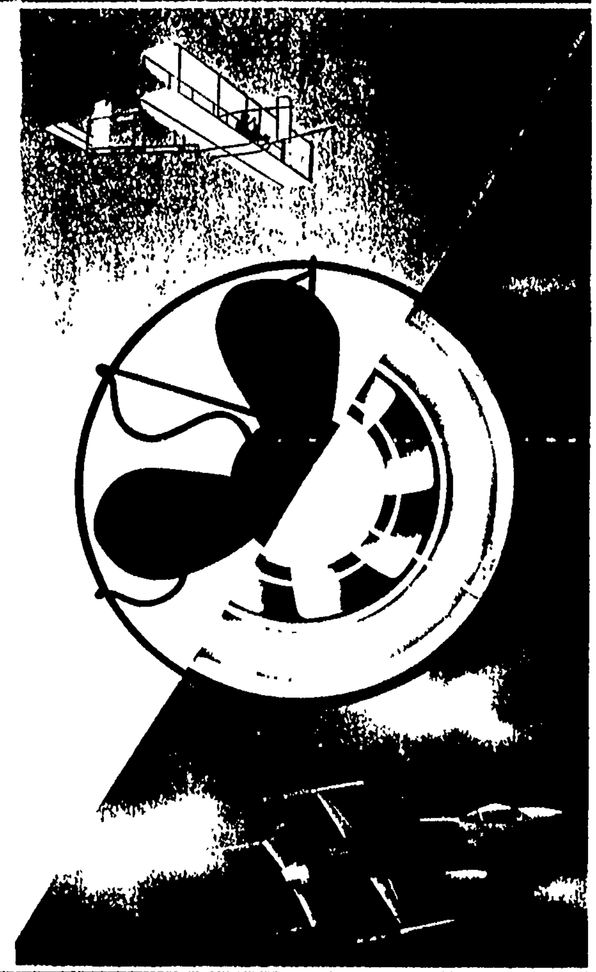
USE OPTIONAL REMOTE PREFILTER UNIT

UNIQUE FAILSAFE DESIGN

To ensure that contaminated air cannot bypass the main filter in the event of a seal failure, the HEPA is clamped between two halves of the main unit. With this arrangement. should a seal failure occur, clean drawn in rather than contaminated air being expelled. A secondary benefit of the layout is that HEPA certification and airflow directional arrows are visible when the unit is fully assembled. A back-draft sh on the outlet duct prevents possible contamination due to reverse flow caused by the wind when the uni shut down. Torchcross units are of all welded construction to maximise safety.

Regency Enviromaster Inc.
P.O. Box 3541
West Chester
Pennsylvania 19382
Tel (215) 3440637
Fax (215) 4364983
Toll Free 1-800 USA ENVI

Welcome to...



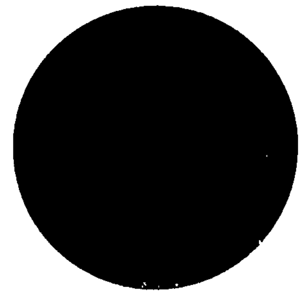
...the world of RAM!

FAN OUTLINE

GPM VS. FAN FLOW

FAN CHARACTERISTICS

RAMFAN™



RAM
centrifugal products, Inc.
240 West 30th Street
National City, CA 92050
(619) 474-7541   FAX (619) 477-8181

3.3 RF 2

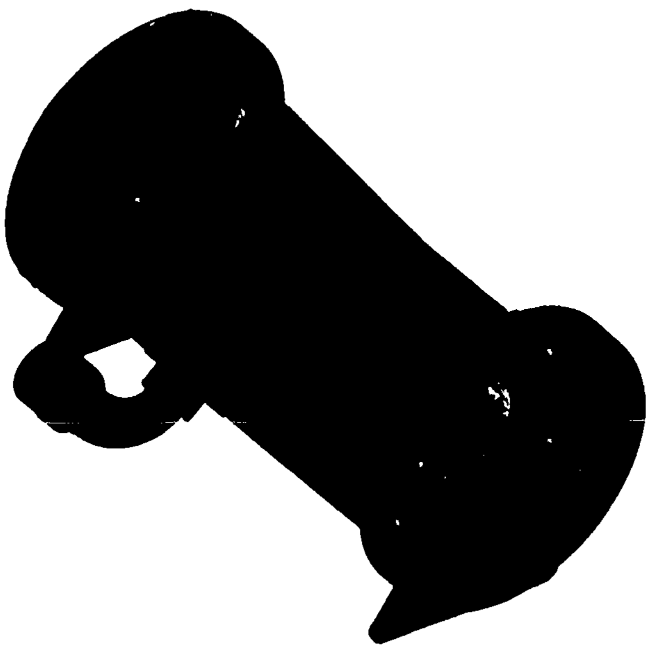
RAMFAN® 2000

Matching High Speed compressor technology with a High Efficiency water turbine drive (pat. pend.), the RAMFAN™ 2000 has pushed the portable blower design envelope into new frontiers.

Converting 150 P.S.I.-1½" firehose output to over 4 shaft horsepower, the RAMFAN™ 2000 will outperform any other unit on the market when pumping gases down twisted, contorted or long lengths of flexible duct. Configured for high velocity jet blast applications, this unit will propel air at over 250 f.p.s. at 1600 C.F.M. providing positive pressurization or mist cooling effects.

Combined with the inherent safety of waterpower, the exceptional lightweight construction (44 lbs.) and the durability to withstand years of constant use, there is no other choice.

+To Boldly Go...
where others won't...



Applications...

- High Velocity Smoke Ejection
- Shipboard Desmoking
- Volatile Atmospheres
- Municipal Fire Fighting

Features...

- Portable - Lightweight
- Ultra High Static Pressure Rise
- Water Power - Non Electrical
- High Flow - High Velocity
- Hot Gas Removal

AFFORDABLE FRESH AIR

IS NOW A REALITY WITH EXCLU SIEVE™ TOTAL ENERGY RECOVERY

All facilities could benefit from the introduction of more outdoor air. Efforts to save energy by cutting back on fresh air quantities has created the age of the
This epidemic has made inevitable, code revisions mandating more outdoor air.

Effective total energy recovery allows more outdoor air while reducing both energy consumption and project first cost. EXCLU-SIEVE™ provides 80% total recovery efficiencies which dramatically
needed to condition the outdoor air.

EXCLU-SIEVE™ represents a major breakthrough in the field of rotary air to air total energy recovery. Its patented transfer surface

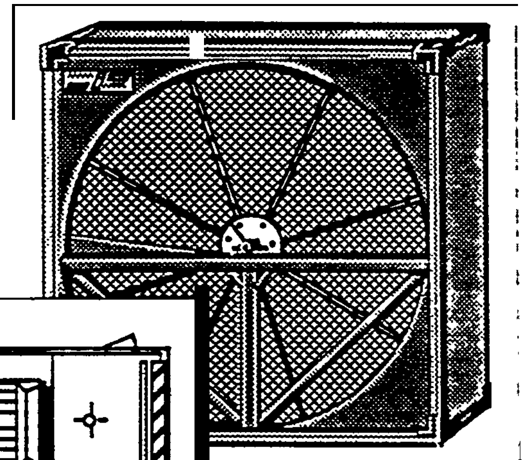
through "selective adsorption" made possible by advanced molecular sieve technology. EXCLU-SIVES certified performance is far superior to all others.

By avoiding desiccant cross-contamination, EXCLU-SIETMV has been applied successfully to such critical applications as animal breeding areas, disease research, chemical laboratories and medical facilities.

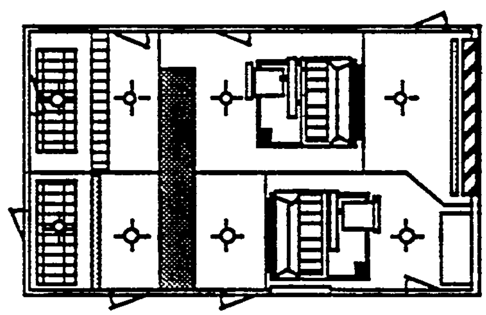
EXCLU-SIEV™ is marketed as an individual component, as a retrofit kit for any existing energy wheel and its controls or as a preengineered packaged air handling system. These energy recovery systems provide for single source responsibility, insure quality and simplify the engineering designgn process.

The EXCLUSIEVE™ control system consists of an A/C frequency inverter and four thermistor sensors which insure maintenance-free operation and document performance. A performance is availible for EXCLU-SIEVE™ applications, revering both parts and labor.

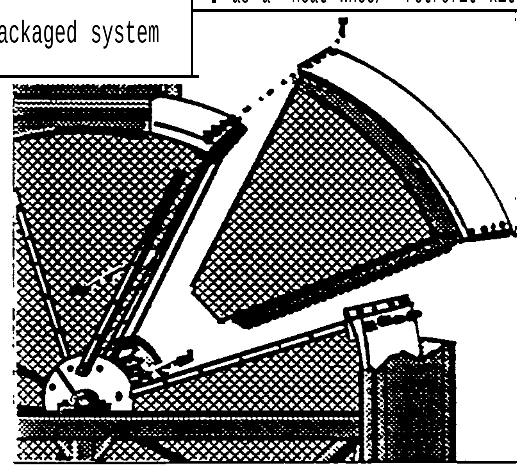
For product information and design assistance contact your local SEMCO EXCLU-SIEVE™ representative or call SEMCO directly at (314) 443-1481.



. as an individual component



. . as a preengineered packaged system



. as a "heat whee/' retrofit kit

THE
SEMCO
AIR
SYSTEM

CLEAN AIR IS OUR BUSINESS

A System for Every Need

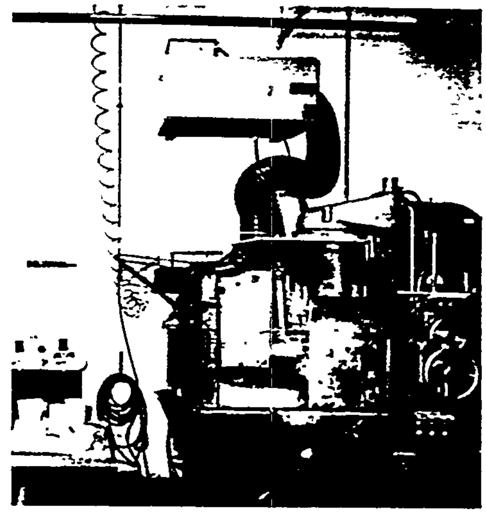
The following pages present the most complete line of air cleaning and dust collection products available from one manufacturer. From the smallest office, restaurant, lounge or lab to the largest factories and process plants, TEPCO can supply air cleaners that clean and recycle air without wasting conditioned indoor air. This means that energy savings alone often pay for the cost of a system. TEPCO systems also protect workers by lowering their exposure to dust, smoke or fumes, thereby improving safety features for your shop or plant. TEPCO cleaned air will also make your customers more comfortable, resulting in increased business for your establishment.

TEPCO commercial air cleaners can be applied to restaurants, lounges, bingo centers, taverns, bowling facilities, schools, hospitals, labs, offices, data processing centers and conference rooms.

TEPCO Space Saver 1000 ceiling mount unit capturing tobacco smoke in hospital lounge.

TEPCO commercial, packaged products include electrostatic air cleaners, non-electrostatic (media filter) alr cleaners and optional odor control modules for some units. Highlights of this line include our Space Saver 1000 and M-500 drop-in, ceiling mounted air cleaners for suspended ceilings, and our high efficiency H EPA units for labs or clean room atmospheres.

TEPCO Space Saver 1000 installed in a restaurant collecting tobacco smoke.



TEPCO Model 600 source capture units mounted c machine tools capturing oil mist.

TEPCO packaged industrial air cleaners have successfully been applied to areas of welding, grin machining, diesel repair, wood working, auto body repair, fiberglass work, metal dust, textile dust, labs schools and hospitals.

TEPCO industrial packaged products include stationary or portable electrostatic air cleaners, stationary or portable non-electrostatic (media filter) cleaners available with optional gas and odor contr modules (media units only).

Highlights of our packaged industrial products in individual electrostatic air cleaners for machine too flowerless electrostatic air cleaners for existing in systems, a complete line of non-e/ectrostatic (medi filter) air cleaners for use in atmospheres not recor mended for electrostatic equipment.

TEPCO Rollaway source capture unit, collectir welding smoke in a repair shop.

Additionally, our Industrial air cleaning line inclu self-cleaning, water wash electrostatic precipitators These systems are built-up units. custom engineere specific applications and air flows.

APPLICATION, SALES, SERVICE

Before Air Cleaners

The TEPCO Difference

TEPCO products are engineered for quality. Years of painstaking research, attention to the smallest detail and strong desire to produce a quality product has gone into every product we manufacture. This persistence has paid off because our customer list contains names of satisfied users from around the world.

With Air Cleaners On

Local representation of our products is available through our network of established, factory trained, full service distributors located in each of the fifty states, Canada, Mexico, Western Europe, South America, Middle East and Far East.

Our full service distributors are specialists in all phases of air cleaning and dust collection, they continually undergo updated training on state of the art design techniques and they can handle new construction or retrofit jobs.

This means that you can have proper representation of the TEPCO products you purchase no matter where you are.

Quality products. quality representation and the broadest choice of air cleaners in the industry that's the TEPCO difference.

Let your local TEPCO distributor survey your business or plant. He can help you properly apply our extensive line of equipment and forecast cost savings available by recycling interior air. TEPCO systems don't cost, they pay.

Application

TEPCO self-contained and built-up air cleaning products are designed expressly for the two methods of ventilation in use today general air cleaning (dilution ventilation) and source capture air cleaning (local ventilation).

General air cleaning with TEPCO air cleaners is shown in figure 1 & 2 below. This method is desirable in any application when source capture is not practical or economical.

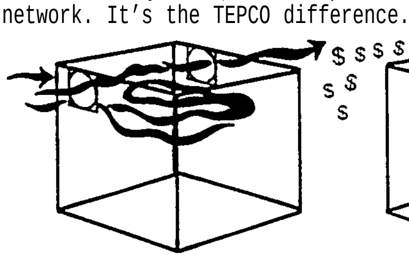
By establishing a proper air exchange rate for a room or facility and an effective air pattern that will entrain and capture airborne contaminants, general air cleaning is a very effective means of cleaning and recycling ambient interior air.

We offer 22 different models of air cleaners made specifically for general air cleaning applications with units that are easily wall, ceiling or floor mounted in either offices or plants.

Source capture of airborne contaminants (figure #3) should be used whenever possible. The obvious advantage source capture provides is that airborne contaminants can be isolated before entering employee , breathing zones. Source capture of contaminants generally requires less CFM to do the same job general air cleaning does, thereby keeping equipment size and costs down.

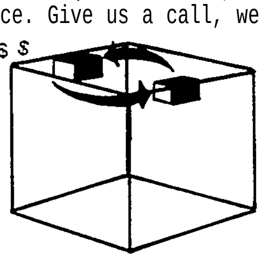
TEPCO has 10 different air cleaning models that can be used in source capture configuration by adding duct work and custom hoods in addition to 7 other models "packaged" expressly for local capture of contaminants.

The bottom line is this: TEPCO offers the most complete line of air cleaning and dust collection equipment available anywhere, and we provide representation, backup and support through an extensive local distributor network. It's the TEPCO difference. Give us a call, we're anxious to help.



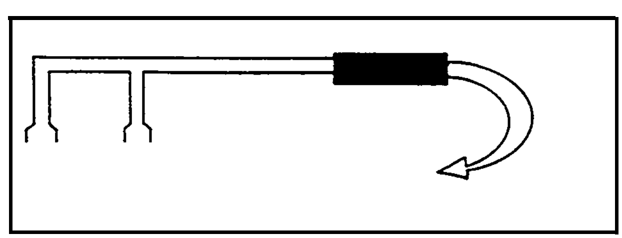
Exhausting interior air contaminants is throwing money away...

FIG. 1



TEPCO air cleaning "recycles" interior air. saving hundreds maybe thousands of utility dollars yearly!

FIG. 2



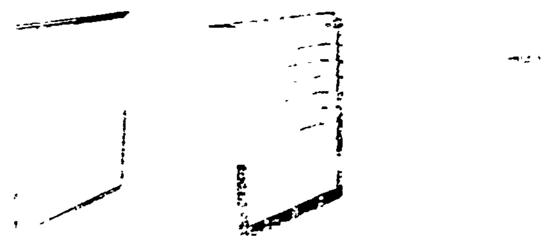
MULTIPLE SOURCE CAPTURED CONTAMINANT HOODED TO MAIN TRUNK LINE

FIG. 3

TEPCO GIVES YOU A CHOICE!!!

Electrostatic Precipitation

Electrostatic precipitation is a time proven operation which utilizes electrostatic forces to separate and capture suspended particles from the air. Based on the principle that matter can be given an electrostatic charge, after prefiltering (1), we pass smoke- and dust-laden air through an intensive electrostatic field in the ionizing section of our units (2) thereby imparting a charge to every particle suspended in the air stream. The charged particles then attach to oppositely charged collector plates (3) allowing the clean air to be discharged back into the internal or external atmosphere.



1. PREFILTER 2. IONIZER 3. COLLE CEL

TEPCO was one of the first companies in the industry to design and manufacture packaged two stage (static precipitators and over the years we have led the industry in technical improvements for both packa(and built up products.

Our original designs and specifications using aircraft quality aluminum construction of collection components. non-convoluted collection plates, and 11 point cell connection construction still set the in standard for high quality commercial or industrial grade packaged electrostatic precipitators.

TEPCO electrostatic air cleaners are ideally suited for use in capturing many types of dry or liquid air particles and with over 20 models and sizes to choose from, the correct TEPCO system can easily be ap to fit your specific need.

Media Filtration

TEPCO packaged media filter products employ all three methods of media air filtration: straining, interception, and impingement in one unit through use of high efficiency prefilters and deep pocket bag filters.

TEPCO Media air cleaners are very desirable for use in capturing many types of dry or liquid airborne particles and are often applied to areas such as conductive dusts, high dust loading, or combustible dust not completely suitable for electrostatic precipitation.

1. PREFILTER 2. MICRO GL FILTER

TEPCO Media filtration utilizes various prefilters (1) to remove the larger dust particles; (2) followed by high efficiency bag filters with numerous pockets made of tightly woven fibers. The tight weave of the fibers forces the air to change directions many times as it travels through the filter. Particles resist change in direction because of th inertia and attempt to continue on in their original directions. As a result they collide with and adhere to filter fibers. Clean air is then discharged back into the internal or external atmosphere. TEPCO also offe optional HEPA filters for most units.

Many different filter options can be used in our media series equipment. Unique features pioneered b TEPCO for this line include lower air to cloth ratios, and larger bag areas of all of our bag filters. Reusal bag filters and adsorption options for special odor or gas control applications are also available.

These unique features mean that TEPCO packaged media air cleaners will cost much less to own anc operate; filters last longer and are applied for each individual customer's needs.

Which Is Better?

The answer depends on *your* specific application or applications. We have successfully applied electro air cleaners to offices, lounges, restaurants, computer rooms, labs, auto body shops, factories, schools, n and even to process emissions. Many of the units in these applications have been on line for more than 15

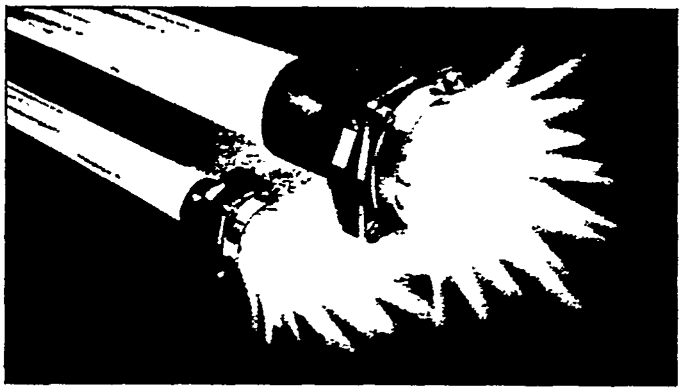
We have likewise successfully applied media filter air cleaners to most of the same applications as o electrostatic air cleaners with equal success. One factor, however, separates TEPCO from all of our competitors: we sell, service and install *both* types of equipment because *both* types work well in selec applications. Actually many customers use a combination of both types of TEPCO systems in one facili from offices to shops or plants because they know TEPCO can supply the proper air cleaners and dust collectors for their needs. There is no need to have something forced upon you because it may be the o product a certain company offers for sale.

TRANSVECTORS

Ventilate - Dry - Convey - Cool

What Isa Transvector?

A Transvector is an airflow amplifier that uses a small amount of compressed air to move dramatically larger volumes of air. In ducted applications, Transvectors deliver amplification ratios of 12-20:1, capable of flows to 2400 CFM. Unducted amplification ratios exceed 60:1. You control a Transvector's output by adjusting input with an ordinary air line pressure regulator. Transvectors may be used to replace fans and blowers in countless applications. without the drawbacks of that equipment, and with far greater efficiency and less noise than venturis, coandas, ejectors. and other compressed-air-powered air movers. They have excellent pressurelvacuum characteristics, making them [deal for air conveying and fume exhaust.

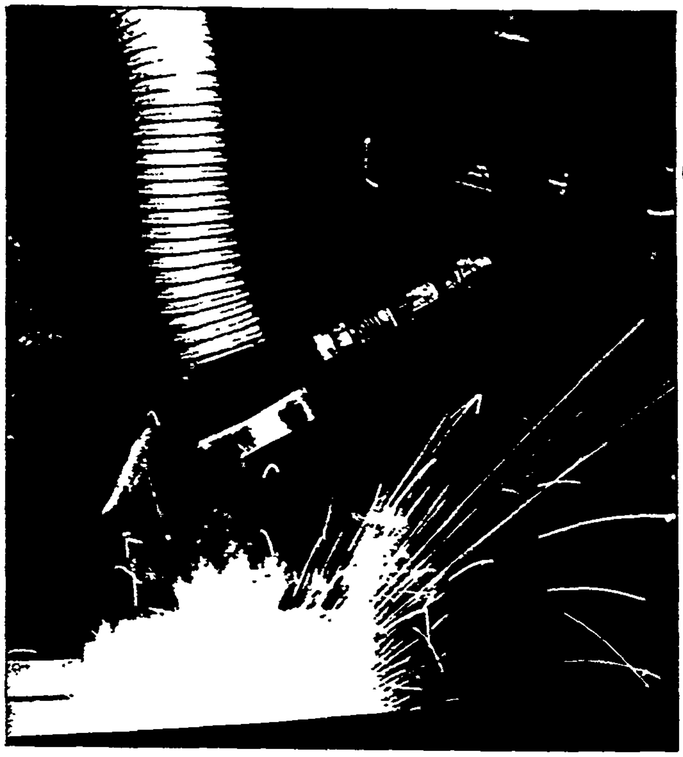


:#~_rs's - lafw unounta d a ir. jut Ilka fan, using nothing mom than Wmpfuad air for paww.

Benefits of Transvectors Over Fans

- No moving parts. maintenance free.
- Easily controlled output.
- No electnclty, exploslon hazarct, or RF interference.
- Fraction of the cost of varfable-soeed blowers or fans.
- No guards or safety hazards.
- Instant omoti.
- Quiet - meets OSHA requwements.
- Easily mounted. ducted. moved.
- Performs alr conveying at atmospheric pressure without alr locks.

'Jdea Caas8Ke an TfanW8CIOM ava.mcia (or loan.



Tranavutomamid ulforwaldlngamob duuet.

Beats Coandas, Venturis, Ejectors, Too

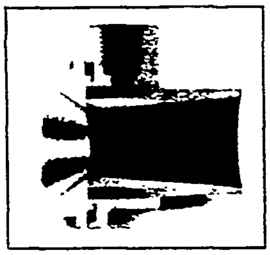
- No internal obstructions.
- More efficient - greater flows with less compressed air.
- No screams or whistle.
- More compact.
- Lower initial cost.
- Easily adapts for smoke and fume control.

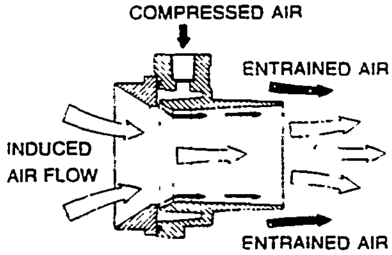
How Is Industry Using Transvectors?

- Air conveying any material that can be moved in a rush of aic gram, plastic pellets, sawdust. powder, capsules. metal chips, paper and cloth trim. lint. dust. small parts. stamrxrq scrap, lead shot. etc.
- Ventilation and exhaust of welding and machining smoKe. auto exhaust, plating tank fumes, and other pollutants.
- Purging tanks of explosive or poisonous fumes.
- Weigh sorting of pharmaceuticals and other light items.
- Surface cooling of workers, electromc cxmtrols.
- Cooling molded parts, castings.
- Drying printing inks.
- Creating air curtains.

How Does a Transvector Work?

The Transvector uses an impulse principle to accelerate a large mass of stationary air with a thin sheet of soruc-veloctty compressed air. When compressed air enters the Transvector. it fills a chamber which has only one exit path: an annular orifice .002" wide. As the air passes through this orifice. It accelerates to 1000 FPS. A lip on the orifice deflects the compressed air down the throat of the Transvector. where It collides with surrounding air and accelerates great masses of free air toward the outlet. It is a s]mple energy transfer process. similar to a break in a pool game. A few htgh speea particles of air collide with still air parucles. resulting m a greater number of particles moving at moderate soeed.



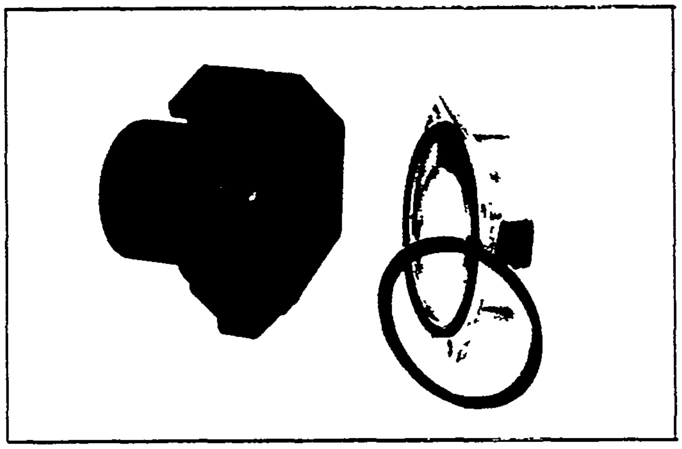


The secret of the Transvector lies in its ability to maximize the speed of the compressed air it releases. Energy released by the compressed air as it strikes the still air increases by the square of its velocity.

For a more detailed explanation of this principle, read the "Short Course on Transvectors" beginning on Page 33.

Getting Started With Transvectors

Transvectors perform the same functions as fans and blowers, so if you are familiar with those types of equipment, you should find it easy to specify Transvectors. However, you may have some "what if" questions. You can get answers to those questions from our Application Engineers. They have assisted customers with virtually every conceivable application for Transvectors, and they are anxious to share that experience with you. Be sure to ask for our free audio cassette seminar on Transvectors. We'll be happy to loan you a copy of our video seminar, too.



The flow through a Transvector can be increased by changing the gap shim, available as an accessory

Specifying a Transvector

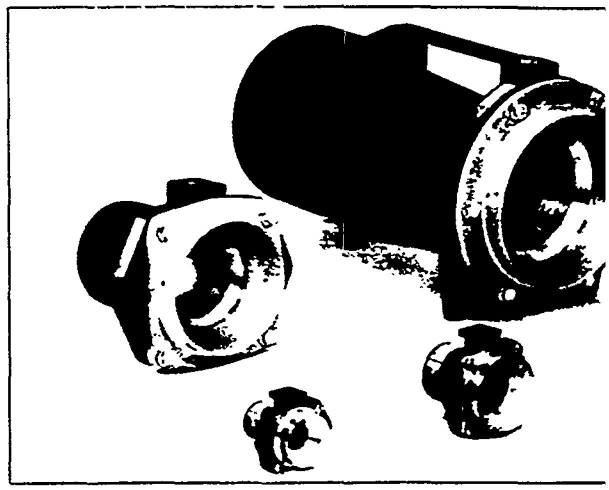
The performance chart, which uses the basic amplification ratio, shows the total ducted output capacities of the four sizes of Transvectors we offer. The total flow is the sum of the induced flow and the compressed-air flow, the two components of the ratio.

To select a Transvector for ducted applications, simply calculate the total flow you will require and specify a model which will meet that requirement. For optimum performance, keep the resistance of the inlet or outlet ducting below 2" W C. Outlet flows decrease at higher resistances.

To determine the compressed air consumption for any model at any pressure, simply divide the total output flow shown in the graph by the basic amplification ratio. For

Materials of Construction

All Transvectors are manufactured from zinc and aluminum alloys. In addition, the model 913/953 is available in stainless steel for use in food, pharmaceutical, or corrosive-environment applications.



Transvectors offer ducted capacities of 25-2400 CFM.

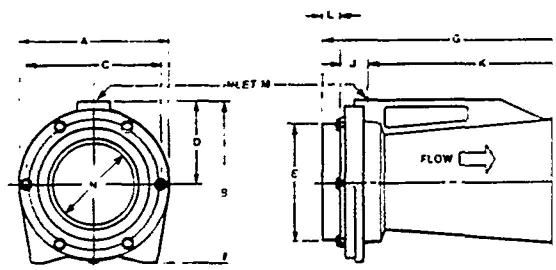
Performance of Transvectors

Transvectors may be used either ducted or unduct **basic amplification ratio** is a measure of air amplificat ducted installation.

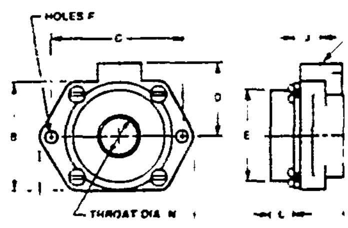
The **entrainment ratio** is for unducted application three times greater because it takes into account the ad *entrainment of air surrounding the output stream of an* unducted discharge. The effect of entrainment normall a few feet from the Transvector's outlet.

MODEL	BASIC AMPLIFICATION RATIO DUCTED APPLICATIONS	DUCTED OUTPUT	ENTRAINME UNDUCTED AP
912-952	12:1	25-100 cfm	36:
913-953	19:1	150-450 cfm	57
914-954	20:1	440-1000 cfm	60
915-955	20:1	750-2400 cfm	60

example, a model 913 delivering 370 CFM total output consumes about 19.5 SCFM compressed air. This is fo dividing 370 by the basic amplification ratio of 19.



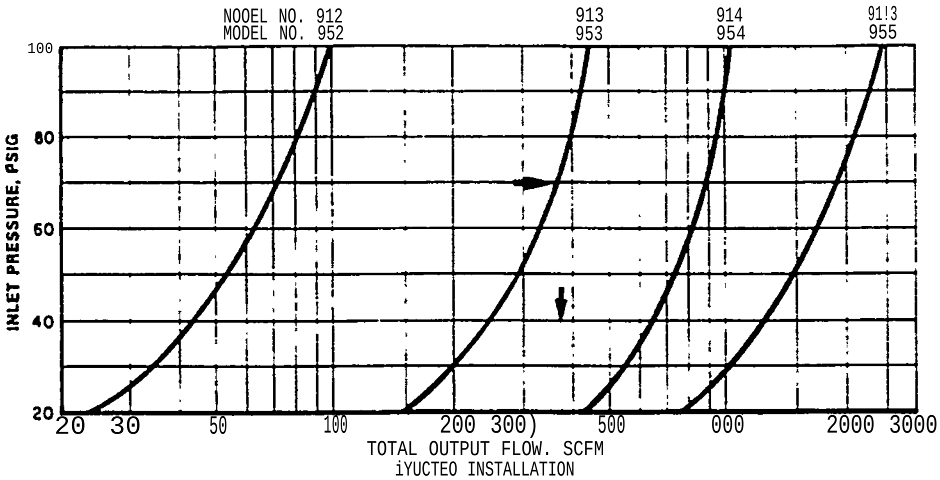
Model 915/955



Models 912/952 913/953 91

MODELS	A	B	C	D	E	F	G	H	J	K	L	M	N
912/952	3 00 76mm	2 06 52mm	2 50 64mm	1 38 35mm	1 75 44mm	27 7mm	2 50 64mm	1 25 32mm	59 15mm	1 00 25mm	50 13mm	¼ NPTF	79 20mm
913/953	4 06 103mm	3 00 76mm	3 56 90mm	1 94 49mm	2 75 70mm	27 7mm	3 22 82mm	2 00 51mm	72 18mm	1 35 34mm	62 16mm	⅜ NPTF	1 57 40mm
914/954	7 75 197mm	6 06 154mm	6 50 165mm	3 50 89mm	5 00 127mm	53 13mm	6 82 173mm	4 00 102mm	1 32 33mm	3 78 96mm	1 00 25mm	½ NPTF	3 00 76mm
915/955	9 38 239mm	9 88 251mm	8 437 214mm	5 12 130mm	7 00 178mm	N/A	17 40 442mm	8 00 203mm	1 78 45mm	14 62 373mm	1 00 25mm	¾ NPTF	5 00 127mm

Transvector Performance Curves

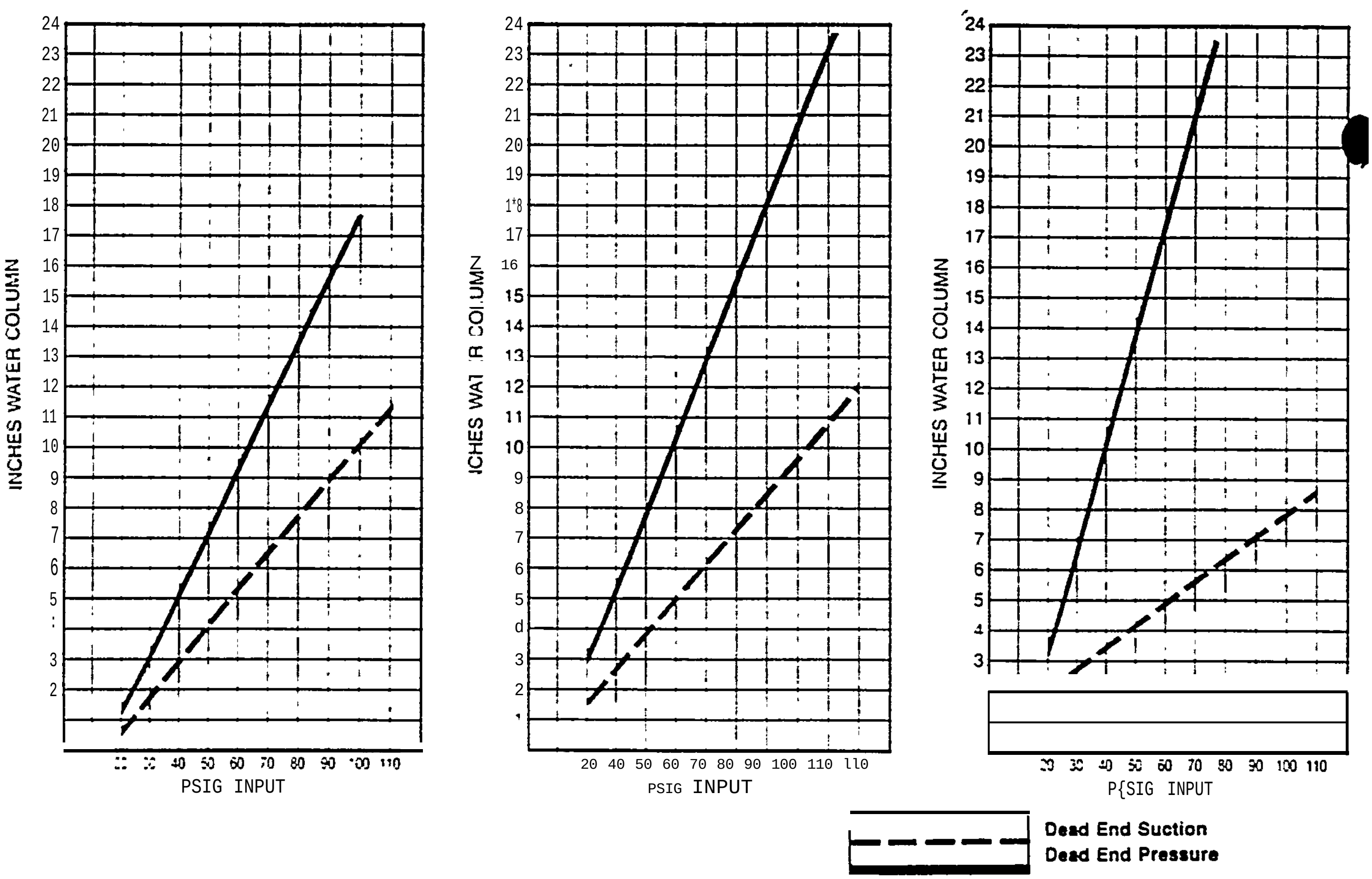


Because of the water and dirt contaminants IN most factory air systems. we recommend a filter in the compressed air line to prevent clogging of the annular orifice. Transveotor models 912, 913.914 and 915 include a 5-micron, automatic-drain filter with bowl; guard. Transvector models 952, 953,954 and 955 are variable-flow units and include the filter system plus an adjustable pressure regulator and gauge. Variable-flow Transvectors operate independently of changes in plant line pressure and allow you to adjust your system for minimum compressed air use.

912/952 Transvector

913/953 Transvector

914/954 Transvector



3.4 AMERICAN WELDING SOCIETY

Contents

New Items

Four Easy Ways To Order From AWS...

CALL 800-334-9353 FOR ORDERS ONLY
(Others please call **800-443-9353**);
All Florida call **800-423-9353**

Write to: Order Department
American Welding Society
550 N.W. LeJeune Road
P.O. Box 351040
Miami, Florida 33135

FAX: **305-443-7559**

TELEX: **51-9245**

AWS Standards — Other Sources

AWS Standards are also available from:

Australian Welding Institute
2nd Floor, Eagle House
118 Alfred Street
Milsons Points, NSW 2061
Australia
Telex. 10101 AUWELDINST

Suministros Asociados S.A.
Belgrano 321
1642-San Isidro, Buenos Aires
Argentina
Phone: 743 2820
Telex: SENSOR AR 26046

Nederlands Normalisatie-institute
Postbus 5059
2600 GB Delft
Netherlands

Microfilm Only:

Information Handling Services
15 Inverness Way East
P.O. Box 1154
Englewood, CO 80150
(303) 790-0600

Photocopies Only

Global Engineering Documents
2625 Hickory Street
P.O. Box 2504
Santa Ana CA 92707
(714) 540-9870

New Item

SP Sate practices, 36 pp. 1987. Reprinted from Welding Handbook vol. 1. Eighth Edition (available October 1988)
This docttment covers the basic elements of safery applicable to all welding. cutting and relared processes. Sutbjects such as fumes and gases. precautionary labeling, handling of compressed gases. the electrical safety in addition to hazards that are unique to partic-lar welding or cutting prccsses. are addressed. A supplementay reading list is includcd.
code: SP price:List $16.00 Meber: $12.00

TWFR Toxicity of Welding Fume in Rats, 186pp, 1986t
This report contains results of a study made on the toxicity of welding fumes in rats. Six welding fumes were administered to rats by inhaiation to determine relative ranking of toxiciry. Fumes were generated from E6010. E7018, E70S-3, E70T-1. E308-16 and E5356 consumables. Results were evafuated in terms of acute inhalation toxicity. pulmanary pathological and fibrogenic poten-tial. in vivo cytogenetic potential and mutagenic potential or urinary excretions. Sampling in the chamber included measure-ment of particle concentration and size. ozone. carbon monoxide. and oxrdes of nitrcgen. The Summary Report contains the text of the study findings and selected tabular data. The Complete Report contains the same text. With tabular data in its entirety.
Complete Report
code: TWFR-C Price: List $100.00 Member: $75.00
Summary Report
code: TWFR-s price: List $32.00 Member: $24.00

ULR Ulthraviolet Reflectance of Paint, 94 pp. 1976
Data on reflectance of a number of indoor and outdoor painted surfaces.
code ULR Price : List $32.00 Membcc $24.00

WFC Welding Fume Control with Mechanical Ventilation, 46 pp. 1981
Guide to design and installation of mechanical ventilation systems.
code WTC Price : List $16.00 Member: $12.00

WFDP Welding Fume Control, A Demonstration Project, 65pp. 1982
Results of a welding fume control studv of three exhaust methods.
code WFDP Price: List $24.00 Member $18.00

F1.1-85 Sampling Airborne Particufates Generated by Welding and Allied Proesses, Methods for, 8pp. 1985
Code FI.1-85 Price: List $12.00 Member $9.00

FI.2-85 Measuring Fume Generaton Rates and Total Fume Emission for Welding and Allted Processes, Laboratory Method for, pp. 1985
Code: F1.2-85 Price: List $12.00 Member: $9.00

F1.3-83 Evaluating Contaminants in the Welding Environment: A Sampling Strategy Guide. 10 pp. 1983
Code F1.3-83 Price List $12.00 Member: $9.00

F1.4-87 Methods for Analysis of Airbome Particulates Generated by Welding and Allied Processes, 18 pp. 1987
This standard contains recommended methods for anatvsis of metal fume constituents. including chromium. and fluoride in welding fume. based on those used by the National Institute of Occupational Safety and Health. It complementsAWS F1.1-85.
Code: F1.4-87 Price: List $16.00 member: $12.00

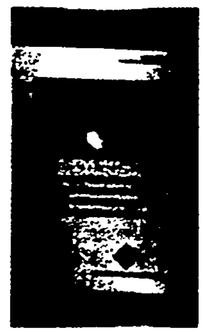
FI.5-87 Methods for Sampling and Analyzing Gases from Weldi Allied processes, 36 pp. 198*
This standard contains recommended samplingmethods an bytical techniques for ozone. carbon monoxide.nitnc oxide. gen dioxide. and gaseous fluoride in welding envrronmen complements AWS F1. 1-85 and AWS F1.4-87.
Code F1.5-87 Price: List $16.00 Member:

F2.1-78 Electron Beam Welding and Cutting, Recommended Practices for, 8 pp. 1978
Code: F2.1-78 Price List $12.00 Member

F2.2-84 Lens Shade Selector, 1984
11" x 17" wall chart Recommended eye protective le various welding promsses.
Code: F2.2-84 Price List S4.00 Member:

New Item

F4,1-68 Preparation for Welding and Cutting of Containers Have Held Hazardous Substances. mended Safe Practices for the, 12pp



This standard informs the reader of the sary safe pracuces to be followed in the ing and preparation for welding or cut containers that have held hazardous s ces. It describes various methods for cl including water, steam. hot chemic mechanical. and techniques to be us preparation such as inerting.
price: List $12.00 Member:

F6.1-78 Sound Level Measurement of Manual Arc Welding and ting Processes, Method for 8 pp. 1978
Code F6. 1-78 Price List $12.00 Member:

New Item

Z49.1-88 Safety in Welding and Cutting, 50 pp. 1988

This standard covers all apects of saf health in the welding environment. em ing oxyfuel gas and arc welding pro with some coverage given to resistance ing. It contains information on protec personnel and the general area. venti tire prevention and protection. and c spaces. A significant scction is devoted cautionary labeling showing exampl an extensive bibliography is included
Code: Z49.1-88
Price: List $28.00 Member:

Metallurgy

WM1 Metallurgy, Welding, Carbon and Alloy Steels, G.E Li 3rd Ed
Volume 1 - Fundamentals 474 pp. 1965
Information nceessary to undetdstand welding as a major t steel fabrication.
Code: WMl Price: List $28.00 Member:

An American National St

WELDING FUME CONTROL
WITH
MECHANICAL VENTILATION

William C. Rous, P.E.
Environmental Sciences Unit, Loss Control Department

Fireman's Fund Insurance Companies
P.O. Box 3395, San Francisco. **Califonia 94119**

WELDING FUME CONTROL

INTRODUCTION

Welding operations generally include metal arc welding, gas welding, cutting, arc gouging, brazing, soldering, and coating metals by thermal spraying in addition to joining and surfacing metals by various welding processes.

The various welding operations produce fumes, vapors, mists and gases, which can be health hazards to the personnel exposed to these environments. Fumes are small airborne solid particles formed by condensation of vapors of the solid materials. Vapors are gases formed by heating solids or liquids. Welding fumes are generated when metals are heated to form vapors which condense to solid particles. Mists are small droplets of material that ordinarily are liquid at room temperature and pressure. Gases are formless fluids such as oxygen, nitrogen and air.

Employee exposures to airborne contaminants can be controlled by ventilation to dilute contaminants to safe levels or else capture the contaminants at their sources for removal to eliminate the air pollution. Engineering control of the in-plant airborne contaminants by local exhaust ventilation is the major subject of this booklet. Air sampling procedures and respirator equipment are not discussed.

Designs of workable local ventilation systems use a few basic airflow principles. The major components of Iocal ventilation are hoods, ducts, air cleaner and an exhaust fan. The hoods are used to capture or contain contaminants. The selection of hoods is governed by the way contaminants are generated, as well as their degree of hazard and concentration. The ducts, air cleaner and fan work together to pull the required amount of airflow through the hoods used in the Iocal ventilation system.

Harmful exposures to employees are often identified by employees, management, safety engineers and industrial hygienists. The purpose of this booklet is to seine as an introduction and guideline to the concepts of Iocal exhaust ventilation. Additionally, the design and use of Iocal exhaust systems is discussed after the hazards of airborne contaminants have been identified.

No representation is made or intended that the information or recommendations contained herein will assure full compliance with the standards of any federal, state or Iocal law.

The Industrial Ventilation ManuaI published by the American Conference of Governmental industrial Hygienists (ACGIH) provides a large number of hood designs and design principles. Figures 2 and 3 in this document are reproduced from the ACGIH manual. The address for the ACGIH Committee on industrial Ventilation is: P.O. Box 16153, Lansing, Michigan, 48901.

Figures 6-10 are reproduced from the National institute for Occupational Safety and Health (NIOSH) Technical information Publication No. 76-162 “Recommended industrial Ventilation Guidelines” by J.H. Hagoplan and E.K. Bastress, January 1976. This NIOSH document is availabie from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402

American National Standard Z49.I on “Safety in Welding and Cutting” has a section #8 on Health Protection and Ventilation. As stated in the Abstract “This standard provides detailed procedures and instructions for safe practices which, if followed, will protect personnel and equipment from harm or damage arising from gas and electric welding and cutting operations.” ANSI Z49.I is pubilshed by the American Welding Society, 2501I N.W. 7th Street, Miami, FL 33125.

The more common hazardous” chemical airborne substances encountered in welding/cutting operations are discussed in section A3. There are others which can be checked by consulting the annual publication of the American Conference of Governmental industrial Hygienists (ACGIH), titiled: “Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment.”

This publication does not include general safety considerations such as firefighting equipment, etc.

Many thanks are due to Mr. Harold Trabbold and Mr. William Cheney for their review of this work and their very constructive comments.

A. WELDING FUME HAZARDS

1. AIRBORNE CONTAMINANTS

Fumes and gases generated during welding, brazing, or metal cutting operations can be a health hazard to welders.

The contents of the fumes and gases depend on the materials used in the base metal, filler metal, flux, or the welding rod coating. It also depends on the type of operation. Typical operations include: oxy-acetylene, tungsten inert gas, metal inert gas, electric arc, plasma arc, brazing or soldering.

The most common metals used are various types of steels with a high iron content. Welding rod coatings and cores also contain various metal oxides, hydroxides, silicates, f!uorides, and organic material. Ozone and oxides of nitrogen are the principal toxic gases produced in arc welding. Toxic fumes are generated when metals are welded which contain lead, zinc, cadmium, copper, nickel or beryl-Iium. Some paints and solvents produce toxic contaminants when heated with a welding torch.

2. UNDESIRABLE EFFECTS OF AIRBORNE CONTAMINANTS

Inhaling small doses of a toxic substance over a long period of time causes a chemical to be taken in faster than the body can eliminate it. Harmful effects from the chemical may become noticeable as toxic materials accumulate in the body.

Routine inhalation of very finely condensed particles, such as fumes, can cause irritation and an unacceptable increase in fibrous hardening of the lungs. Inhalation can also cause a detrimental effect to other body functions.

a. Fumes Containing Metal Oxides

The inhalation of iron oxide fumes and dusts given off from steel can produce a benign condition in the lungs called siderosis. Siderosis is a chronic fibrous hardening reaction of lung tissue which can be caused by prolonged exposure to iron fumes.

Fumes from many metals including cadmium, copper, nickel, and zinc can produce metal fume fever. The symptoms are similar to those of influenza and usually occur after a few hours of exposure. The symptoms include a metallic taste in the mouth, dryness of the

nose and throat, weakness, fatigue, muscular and joint pain, fever, chills, and nausea. These symptoms usually last less than 24 hours. A temporary immunity follows which is lost over time periods such as a weekend. As a result, welders are more susceptible to this fever on Mondays or just after a holiday.

1) Some silver solders contain cadmium. Even a brief over-exposure to cadmium fumes can produce severe lung irritation, which may be fatal. Fumes from welding cadmium plated parts can cause severe chest pains, coughing, nausea, vomiting, throat dryness, kidney and lung disease.

2) Chromates in stainless steel can cause nose ulcers and lung cancer. Fluorides from aluminum and stainless steel cause skin irritation, nose bleeding, and general weakness.

3) Zinc oxide from galvanized metal, brass and bronze, and also copper from brass and bronze cause metal fume fever. Severe fever, chills, and exhaustion start about six hours after work exposure and lasts approximately 24 hours. Magnesium fumes from various alloys cause the same effects as zinc oxide.

4] Lead fumes from painted metals, and alloys such as brass and bronze, can cause long-term nerve disorders. Symptoms are stomach cramps, constipation, weakness, and weight loss.

5 Exposure to mercury from paint on metals results in abdominal pains, vomiting, diarrhea, pneumonitis, kidney damage, and very severe circulatory or respiratory problems.

6) Fumes from nickel alloys can cause changes in lung tissue including pneumonia. Molybdenum, titanium, and vanadium alloys cause respiratory tract irritations. Vanadium also causes severe eye irritation.

7) Manganese in alloys can cause neurological lesions with symptoms of weakness in legs and difficulty walking downhill.

8) Beryllium alloys can cause very serious chronic lung disease with symptoms of coughing and resembling tuberculosis in X-ray diagnosis.

b. Gases

1) Inhaling carbon monoxide from incomplete combustion of fuel gases interferes with the oxygen-carrying capacity of the blood resulting in drowsiness, headaches, and dizziness.

2) Ozone from arc welding and cutting irritates the eyes, nose and throat and can produce pulmonary edema and hemorrhage. Edema is the presence of abnormally large amounts of fluid in the intercellular tissue spaces of the body.

3) Nitrogen dioxide and nitrous oxides can be formed during arc and gas welding which will cause throat and nose irritation and also may lead to severe lung damage.

4) Phosphine from welding of phosphate coated steel used in rustproofing can cause irritation of eyes, nose and skin.

5) Phosgene can be produced from heating metals coated with chlorinated hydrocarbons in decreasing solvents or when chlorinated hydrocarbon vapors are present. Phosgene is primarily a lung and respiratory irritant producing chest pain, vomiting and excess fluid in the lungs. This condition is serious and can easily be fatal, especially since warning characteristics are not present.

6) Available oxygen in the air can be reduced due to the presence of carbon dioxide, argon, or helium used for inert shielding gases. The main effects are impaired muscular coordination and diminished mental alertness.

3. FEDERAL STANDARDS
[OSHA Standards, Title 29 CFR part 1910.252(f)[

When an Industrial Hygienist makes a survey for the presence of potentiality hazardous substances, a report of the findings is made of airborne contaminant concentrations relative to Federal Standards adopted under the Occupational Safety and Health Act of 1970 (OSHA). Time-weighted threshold limit standards are based on concentrations at which an average person may be repeatedly exposed day after day without adverse effects. Some state standards are more stringent than federal OSHA standards and should be used where applicable. Time-weighted averages permit excursions above the limit provided they are compensated by equivalent excursions below the limit during the workday. Some substances are better controlled by a ceiling limit which cannot be exceeded.

The American Conference of Governmental Industrial Hygienists (ACGIH) has issued Threshold Limit Values (TLVs) for airborne chemical substances and physical agents in the workroom environment. in some cases, the OSHA values have been modified by ACGIH publications to more stringent values for assuring protection of personnel.

OSHA In conjunction with American Welding Society [AWS) and others has established health protection and ventilation requirements based on three factors in arc and gas welding. These govern the amount to which welders may be exposed, such as:

a) Working space dimensions, especially height of ceiling

b) Number of welders

c) Possible evolution of hazardous fumes, gases, or dust depending on the metal involved.

Other factors which may require ventilation or respiratory protection devices include:

a) Atmospheric conditions

b) Amount of energy used and heat generated

c) Presence of volatile solvents.

OSHA standards include the following guideline Workroom volumes of 10,000 cubic feet or more per welder with room ceiling height greater than 16 feet may use dilution circulating air rather than local exhaust hoods when the material being used is of low order of toxicity. Minimum air movement per welder in this nuisance dust, gases and fume category must be 2,000 cubic feet per minute (CFM) per welder. AWS believes this guideiine can be misleading and dangerous if the total environment is not taken into consideration.

Local exhaust hoods and booths are particularly important in processes where the materials used contain fluorides, zinc, lead, beryllium, cadmium, mercury, or cleaning compounds.

In many welding operations, a freely moveable hood can be placed by the welder as near as practical to the work being welded. The moveable hood is to have a rate of air flow sufficient to maintain a velocity of 100 linear feet per minute in the direction of the hood at the zone of welding when the hood is placed the farthest distance from the point of welding.

For some conditions, welding must be done in a fixed enclosure set up for welding. This fixed enclosure must have a top with not iess than two sides which surround the welding or cutting operation. The air flow rate away from the welder across the weld to the exhaust opening must beat least 100 linear feet per minute to mainrtain a flow away from the welder. The placement of the fan is important since a fan placed behind the welder may cause a whirling or circular air

movement which could increase the concentration of contaminants the welder inhales.

a. Ventilation in confined spaces

1) Air replacement. All welding and cutting operations carried on in confined spaces shall be adequately ventilated to prevent the accumulation of toxic materials, or a possible oxygen deficiency. This applies not only to the welder but also to helpers and other personnel in the immediate vicinity. All replacement air shall be clean and respirable.

2) Airline respirators. in circumstances where it is impossible to provide sufficient ventilation, airline respirators or hose masks approved by NIOSH and MSHA (Mine Safety and Health Administration) agencies for this purpose shall be used.

3) Self-contained units. In areas with conditions immediately hazardous to life, hose masks with blowers or self-contained breathing equipment shall be used. The breathing equipment shall be approved by NIOSH and MSHA.

4). Outside helper. Where welding operations are carried on in confined spaces and where welders and helpers are provided with hose masks, hose masks with blowers or self-contained breathing equipment approved by NIOSH and MSHA, then, a properly equipped worker shall be stationed on the outside of such confined spaces to ensure the safety of those working within the confined space.

5) Compressed air. Compressed air can be used for dilution ventilation. Oxygen shall never be used for dilution ventilation.

b. Fluoride compounds

1) General. In confined spaces, welding or cutting operations involving fluxes, coverings, or other materials which contain fluoride compounds shall be done in accordance with the above requirements for ventilation in confined spaces. Fluorine, as used here, is as an element in chemical combination and not a free gas.

2) Threshold Limit Value. The need for Iocal exhaust ventilation or airline respirators for welding or cutting in other than confined spaces will depend upon the individual circumstances. However, experience has shown such protection to be desirable for fixed location production welding and for ail production welding on stainless steel. Where air samples taken at the welding location indicate that the fluorides liberated are below Threshold Limit Values, such protection is not iikely to be necessary.

c. Zinc

Confined spaces. In confined spaces involving zinc-bearing base or filler metals (or metals coated with zinc-bearing materials) welding or cutting shall be done in accordance with the requirements discussed above for ventilation in confined spaces.

d. Lead

1) Indoors. indoor welding involving lead-base metals shall be done in accordance with the requirements described for ventilation in confined spaces.

2) Local exhaust ventilation. in confined spaces or indoors, welding or cutting involving metals containing lead (other than as an impurity) or metals coated with lead-bearing materials including paint, shall be done using local exhaust ventilation or airline respirators. Outdoors, such operations shall be done using respiratory protective equipment approved by NIOSH/MSHA. Workers in the immediate vicinity of the cuffing operation shall be protected as necessary.

e. Beryillum

Local exhaust ventilation and airline respirators shall be used when welding or cuffing indoors, outdoors, or in confined spaces. This involves beryllium-containing base or filler metals unless atmospheric tests under the most adverse conditions have established that the workers' exposure is within the acceptable concentrations defined by 29 CFR 1910.1000. In all cases, workers in the immediate vicinity of the welding or cutting operations shall be protected as necessary.

f. Cadmium

1) Welding or cuffing indoors or in confined spaces involving cadmium-bearing or cadmium-coated base metals shall be done using local exhaust ventilation or airline respirators. This equipment can be eliminated if atmospheric tests under the most adverse conditions have established that the workers’ exposure is within the acceptable concentrations defined by 29 CFR 1910.1000. Outdoors, such operations shall be done using respiratory protective equipment such as fume respirators approved by the National institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA) for such purposes.

2) confined spaces. Welding or brazing involving cadmium-bearing filler metals shall be done using ventilation as prescribed above for local exhaust hoods or ventilation in confined spaces if work is to be done in a confined space.

g. Mercury

Welding or cutting indoors or in a confined space involving metals coated with mercury-bearing materials, including paint, shall be done using ventilation as prescribed above. This is also applicable for local exhaust ventilation or airline respirators, unless atmospheric tests under the most adverse conditions have established that the workers' exposure is within the acceptable concentration defined by 29 CFR 1910.1000. Outdoors, such operations shall be done using respiratory protective equipment approved by NIOSH and MSHA agencies for this purpose.

h. Exposure Limits for selected harmful metal-based fumes or particulates.

See chart on next page

(This chart does not list all possible contaminants. Check the ACGIH “Threshold Limit Values in the Workroom Environment” for a comprehensive listing.)

MATERIAL	OSHA Standard (1971) See NOTE A below. All units in milligrams per cubic meter (mg/M^3)			ACGIH (1979 TLVs) See NOTE B below. All units mg/M^3	
	8 hr. TWA	Ceiling	Max Ceiling	TWA	STEL
Beryllium	002	005	.025 (30 minutes)	.002	
Cadmium Oxide (fume)	0.1	0.3		c 0.05	
Chromium	0.5			0.5	
Copper (fume)	0.1			0.2	
Lead	0.05 (1979)			0.15	0.45
Manganese (fume)	5.0			1.0	3.0
Mercury		0.1		.05	0.15
Molybdenum	5.0			5.0	10.0
Nickel	1.0			1.0	
Vanadium Oxide (fume)	0.1			c 0.05	
Zinc Oxide (fume)	5.0			5.0	10.0

NOTE A

OSHA Standards use three types of exposure concentration limits. These are:

(1) 8-hour TWA-Concentration not exceeding a time-weighted average during any 8 hour warkshift in a 40-hour workshift in a 40-hour work week.
(2) Celling Value-Concentration shall at no time exceed the ceiling limit.
(3) Maximum Acceptable Celling-Concentration not to be exceeded at any time during an 8-hour shift for maximum time indicated.

NOTE B

ACGIH uses three types of Thresho!d Limit Values (TLVs). These are

(1) Time Weighted Average (lWA)-Limit for overage exposure during 8 hour workday or 40-hour work week.

(2) Celliing VOlues (c)-Concentration that should not be exceeded even instantaneously.

(3) Short term exposure iimit (STEL]-Maximum concentration of exposure for a continuous period of 15 minutes. No more than four of these periods are permitted per day with at least 60 minutes between exposure periods provided the TWA is not exceeded.

1. Cleaning Compounds

In the use of cleaning materials, because of their possible toxicity or flammability, appropriate precautions such as manufacturers instructions should be followed.

j. Miscellaneous-Decreasing, Cutting, First Aid

Decreasing. Cleaning operations involving chlorinated hydrocarbons shall be so located that no vapors from these operations will reach or be drawn into the atmosphere surrounding any welding operation. In addition, the ultraviolet radiation of gas-shielded welding operations should be screened from the chlorinated degreaser vapors to prevent toxic decomposition products.

Cuffing stainless steel. Oxygen cutting, using a chemical flux or iron powder, or gas-shielded arc cutting of stainless steel shall be done using mechanical ventilation adequate to remove the fumes generated.

First-aid equipment. First-aid equipment shall be available at all times. On every shift of welding operations, employees trained to render first-aid should be present. All injuries shall be reported as soon as possible for medical attention. First-aid shall be rendered until medical attention can be provided.

B. GENERAL & DILUTION VENTILATION

1. GENERAL VENTILATION

General ventilation is the general movement of air within rooms and buildings. Natural air movement may take place from external winds, drafts from chimneys, or room thermal convection. General ventilation includes general mechanical ventilation achieved by such means as roof fans.

2. DILUTION VENTILATION

Dilution ventilation is the dilution of contaminated air with the addition of uncontaminated air in a general area, room, or building to control exposure to airborne contaminants which are a nuisance and of low toxicity.

Types of dilution ventilation include pedestal fans or wall fans which circulate air through the work area.

Dilution ventilation is generally not as effective as local exhaust ventilation for controlling health hazards of airborne contaminants.

In some cases, dilution ventilation may be adequate to provide ventilation control. Such uncommon cases exist where toxicity of the contaminant is low, evolution or generation of the contaminant is uniform, the quantity generated is low, and the workers are far enough from the souce. In general, dilution ventilation is seldom successful in removing or controlling welding fumes and dusts to a safe, acceptable level.

C. LOCAL EXHAUST VENTILATION CONTROL

1. GENERAL

Local exhaust systems capture air contaminants very close to the source of contaminants before they are dispersed into the general working area. Dilution ventilation reduces the concentration of contaminants by adding fresh air but does not reduce or eliminate the total amount of contaminants which are released. Numerous conditions exist which can not be improved by using dilution ventilation.

Because of its positive control characteristics, Iocal exhaust ventilation is the most logical approach to engineering control of contaminants. it also has the advantages of being adjustable, and uses minimum amounts of air. Local exhaust ventilation will reduce contaminants to acceptable Ievels in cases where it is correctly designed, built, instailed, maintained, and used by the operator (welder).

Local exhaust systems require design and installation of hoods, ducts, air cleaners, and exhaust fans which are specifically tailored to each application.

2. EQUIPMENT

Every local exhaust ventilation system controls contaminants by having a hood opening which surrounds the source of contaminants as closely as possible. The hood is connected to ducts and exhaust fan to carry contaminants away from the work area. Generally some type of air cleaning equipment is included.

Over the years, specific hood shapes have been developed which are effective for a large number of industrial processes. However, hood design still requires the greatest amount of attention in each application so exhaust ventilation performs as intended.

Approximately six types of hoods or enclosures for welding processes have evolved for carrying off fumes, sprays, smoke, and dust. The six types are

a) Movable or a freely suspended open exhaust hood

b) Cross-draft table

c) Downdraft table (for special situations and with careful design)

d) Enclosing hood

e) Open hood

f) Gun mounted exhaust

Examples of the different types of hoods are given later in section E, titled Local Exhaust Ventilation Equipment.

Hoods and booths are very effective in a fixed location. Exhaust devices located on welding guns are effective but require cooperation from the welder. Moveable exhausters are effective but must be manually repositioned by the welder as needed.

The sizes of ducts, fan, and air cleaner are determined from the volume and velocity of airflow required to capture and transport the airborne contaminants.

D. LOCAL EXHAUST VENTILATION DESIGN PROCEDURE

(as generally followed by Heating Ventilation Air Conditioning (HVAC) professionals)

1. PROCEDURE AND PHASES

Design procedure follows a typical problem solving approach of: Recognizing the problem, identifying possible causes, choosing alternative courses of action, and carrying out the action chosen.

a. Phase I Analysis

When the amount and kind of contaminants from fumes, vapor, or dust have been identified as a health hazard, the designer or person generating system requirements gathers preliminary data consisting of:

1) Layout of operations and workroom.

2) Preliminary line sketch of ductwork elevations and horizontal layout, locations of hoods, fan, and dust collector.

3) Rough design or sketch of recommended hood with the required exhaust ductwork layout.

4] Information on the physical shape and distribution of how the contaminant is generated, and what is the toxicity of the materials from each operation.

5) identifying number or letter to each hood, exhaust duct branch beginnings, endings, junctions; each section of main duct; location and type of all elbows and entries.

6) Controlling the discharge of captured contaminant.

b. Phase II Component Design

The preliminary information generated in Phase I should be sufficient to allow:

1) the selection or design of a hood for each contaminant source location,

2 determining required exhaust air volume rates,

3) determining air velocities needed to capture the contaminant and move it through the exhaust duct system,

4) determining hood entry loss coefficients.

c. Phase Ill System Design

The information from Phases I and ii is used to size the local exhaust system.

Calculations to size the exhaust system include:

1) calculating duct air flow volumes and duct diameters,

2) calculating velocity pressure and static pressure losses,

3) balancing static pressures at duct junctions in the system,

4) determining the overall exhaust air volume, flow rates, and overall pressure drops,

5) calculating the static pressure required by the exhaust fan,

6) selecting the fan and motor.

2. EXHAUST SUBSYSTEMS

Ail local exhaust systems use hoods, ducts and special fittings which lead to an exhaust fan. Most exhaust systems use air cleaning equip ment located upstream in front of the exhaust fan. In making calculations, complex systems can be divided into a number of simple exhaust systems connected to a common duct leading to the air cleaning equipment and fan.

3. MINIMUM AIR VELOCITIES

Where the source contaminant consists of dust or other particles, emphasis is on maintaining minimum air velocities needed to prevent settling in the ductwork. The minimum air velocities in the ducts are not so critical in situations involving exhausting vapors, gases, or non-condensing fumes. Air velocities may be lowered for vapors and gases to obtain lower pressure losses and better operating economy than may be allowable in systems for controlling dust.

Pressure losses take place when air flowing through ductwork meets resistance from friction against the walls of ducts and from turbulence in the air stream. These energy losses are expressed as a pressure drop from additional static pressure. An exhaust fan must generate the necessary static pressure to maintain required air volume flows and air velocities for the exhaust system to work properly. Air pressure friction losses vary as follows:

(a) In direct proportion to duct length, and the roughness of the duct interior surface,

(b) Relative to square of air velocity,

(c) In inverse proportion to the duct diameter.

Most industrial local exhaust systems are made up of galvanized sheet metal ducts. The industrial Ventilation Manual and a number of texts publish friction pressure loss data which are average values for clean, galvanized metal ducts. These ducts have approximately

40 joints per 100 feet and are based on flow of standard air having a density of 0.075 pounds per cubic foot. Corrections for temperatures between 40F and 100F and/or elevations between sea-level and +1,000 feet are seldom required within the allowable variations of the usual exhaust system design.

Turbulent pressure losses result from changes in air velocity and direction of flow. This kind of loss occurs at every hood, elbow, duct enlargement, and duct junction. These losses can be minimized by using (a) tapered rather than abrupt enlargements, (b) gradual entries of a branch duct into another duct (e.g., entries at 30° to main duct), (c) generous radil in elbows (e.g., using an elbow with a center-line radius that is twice the duct diameter).

4. SYSTEM SIZING

Arbitrary limits on the maximum overall size of an exhaust system are difficult to determine. Generally, Iittle is gained by using a single main duct which is more than 1,000 sq. inches (approximately 7 square feet) of duct area. This is approximately 20,000 cfm for a single fan.

Larger systems become unwieldy and inflexible. Also excessive costs can arise from exhaust system repairs or equipment relocation, and shutdowns if such larger capacities are combined into one unit.

Most pressure loss calculations for locaI exhaust systems are based either on “equivalent feet of duct,” or on “velocity pressure loss.” Both methods use the same basic principles of air flow and the same established physical data. Data have been organized into readily useable tables for both methods.

The equivalent foot method uses tables which relate duct diameter, duct radius, angle of branch entry, and exhaust ducts to the equivalent foot length of straight duct. The velocity pressure method utilizes the same information on elbows, duct transitions, and duct exhaust to develop friction pressure loss and provide loss coefficients as a fraction of the velocity pressure loss per 100 feet of straight duct.

The velocity pressure method is based on the fact that all frictional and turbulent losses in exhaust ducts and hoods are directly proportional to the velocity pressure. Loss factors for hoods, straight ducts, elbows, branch entries, weather caps and other fittings are available in terms of velocity pressure.

The procedure to design a local exhaust system starts at the hood located the greatest distance from the fan, then the calculations pro-

teed downstream to duct junctions, then finally to the fan and out to the end of the duct exhausting to the atmosphere.

5. SYSTEM BALANCING

1) Although greater care and more precise determinations are required for balancing without blast gates, the advantages of doing so include:

(a) Air volumes cannot be easily changed at the whim of worker or operators.

(b) Ductwork will not plug if the duct air velocities are correctly chosen.

(c) A poor choice of "the duct branch of greatest air flow resistance" will show up in the design sizing calculations. If this hap pens where blast gate balance is depended upon, the branch or branches of greater resistance will not function properly due to being "starved" for air.

[d) No unusual erosions or accumulation problems are likely to occur.

2) Disadvantages of balancing without blast gates are

(a) the total air volumes may be sIightly greater from added air volumes to achieve balance,

(b) the choice of exhaust volumes for a new unknown operation may be incorrect requiring some ductwork revision, and since the ductwork is "tailormade" for the job, this provides Iittle flexibility for adding equipment or changing equipment locations.

In general, balancing without blast gates is better and the recommended method to use. It is often called the Static Pressure Balance Method. This method is mandatory where pyrophoric materials, highly toxic materials, explosive, or radioactive dusts are exhausted. The reason is to eliminate any possibilities of accumulations in a branch duct caused by a blast gate obstruction.

6. SYSTEM DESIGN

After determination of the type and amount of the airborne contaminants, the general design procedure is to start at the hood farthest from the fan and:

a) Select or design the exhaust hood to contain the contaminant source.

b) Determine the desired air volume and the minimum air duct velocity. Then use these values to calculate the branch duct size.

c) From the layouts of operations and line sketch of ductwork elevations and horizontal paths developed in Phase A, determine the actual length of the ductwork required (calculated as centerline distance along the duct but not including radius of elbows and transitions). Determine the equivalent lengths of elbows and special fittings from reference tables. The equivalent lengths of elbows and other fittings are added to the various duct lengths during the calculation procedure described later.

The Velocity Pressure Method has several advantages over the Equivalent Foot Length Method of duct design. It is generally faster and has the advantage of allowing quick recalculation of branch duct sizes for balancing the static pressures at duct junctions. The Velocity Pressure Method is based on all of the frictional and dynamic losses in exhaust ducts and hoods being directly proportional to the Velocity Pressure. Loss factors for hoods, straight ducts, elbows, branch entries, weather caps and many other fittings are known and published in terms of the velocity pressure. in this method, only one pressure loss value for elbows and fittings need be established when starting the design.

d) Determine velocity pressure losses in the ducts, hood entry loss, and hood suction loss.

e) Determine the static pressure for the duct sections and the governing static pressure and balanced static pressure at duct junctions.

f) Determine static pressure losses in the air cleaning equipment and the exhaust section.

g] Determine the overall static pressure required in the system needed to be generated by the fan.

The local exhaust system design procedure is expedited by use of the many figures of different types of exhaust hoods. Recommendations for a wide range of industrial processes are found in three publications. These are given in the list of references, Appendix IL

7. EXAMPLE CALCULATIONS

The example calculations show basic airflow relationships used in designing local exhaust ventilation systems. They provide both a qualitative and quantitative introduction to principles of airflow in ducts.

a) Calculate duct velocity for a 6 inch diameter duct carrying an air volume at the rate of 400 cubic feet per minute (CFM).

$$\text{Velocity} = \frac{\text{Air Volume Flow Rate}}{\text{Area}}$$

The area of a 6 inch diameter duct is 0.1964 square feet.

$$\text{Velocity} = \frac{400 \text{ CFM}}{0.1964 \text{ sq. ft.}} = 2037 \text{ feet/min (fpm)}$$

b) Calculate the velocity pressure (VP) resulting from an air velocity of 2037 fpm.

$$V = 4005 \quad \sqrt{VP}$$

$$VP = \left(\frac{V}{4005}\right)^2 = \left(\frac{2037}{4005}\right)^2 = (0.51)^2 = 0.26 \text{ in. w.g.}$$

c) Calculate the friction loss for a 6 inch diameter and 55 foot long duct, carrying air at 400 cubic feet per minute (CFM).

Note: Solutions for this type of calculation, and for some of the following example calculations, are usually obtained by using graphs found in the Industrial Ventilation Manual, reference c, Appendix IL

Figure 4 gives Duct Friction Loss for round ducts expressed as velocity pressure equivalents per 100 foot of duct length. The 6 inch diameter almost horizontal curve in Figure 1 intersects 400 CFM diagonal at 4.4 VP per 100 ft. of duct on the vertical axis.

Multiplying 4.4 VP per 100 ft x $\frac{55 \text{ ft}}{100 \text{ ft}}$ = 2.42 VP friction loss.

Using the 0.26 Inches w.g. velocity pressure (VP) due to 400 CFM in a 6 inch diameter duct found in calculations 7a and 7b on page 7:

2.42 VP = 2.42 x 0.26 inches w.g.
= 0.63 inches w.g. friction loss for 400 CFM through 55 ft. long 6″ dia. duct.

d) Calculate the friction loss for two 90° elbows, 6 inches in diameter, one with a centerline bend radius 2 times the duct diameter, the other with a bend radius of 1:25 x duct diameter.

Fig. 2 gives a loss fraction of velocity pressure (VP) for a 2.000 elbow as 0.27, and for 1.25D elbow as 0.55.

The velocity pressure for a 6 inch dia. round duct was determined in 7(b) above as 0.26 in. w.g.

(0.27 is VP Ioss fraction for 2D elbow) x 0.26 in. w.g. = 0.07 in. w.g.

(0.55 is loss fraction for 1.25D elbow) x 026 in. w.g. = 0.14 in. w.g.

e) Calculate the pressure loss for two 90° elbows 6 in. dia. round plus 45° elbow 6 in. dia. (45° is equivalent to 0.5 x 90° Elbow factor).

2.5 elbows x (0.27 for VP of one elbow) x 0.26 in. w.g. = 0.176 in. w.g.

Note that:

for 60° elbows, loss = 0.67 x loss for 90°
45° elbows, Ioss = 0.5 x loss for 90°
30″ elbows, loss = 0.33 x loss for 90°

f) Calculate pressure loss for the 6 inch dia. branch duct entering a main duct at 30° angle.

The VP in the 6 inch dia. duct was calculated in (b) above as 0.26 in. w.g.

Fig. 3 gives 0.18 as loss fraction of VP in branch for 30° angle entry.

0.18 x 0.26 inches w.g. = 0.047 inches w.g. pressure loss.

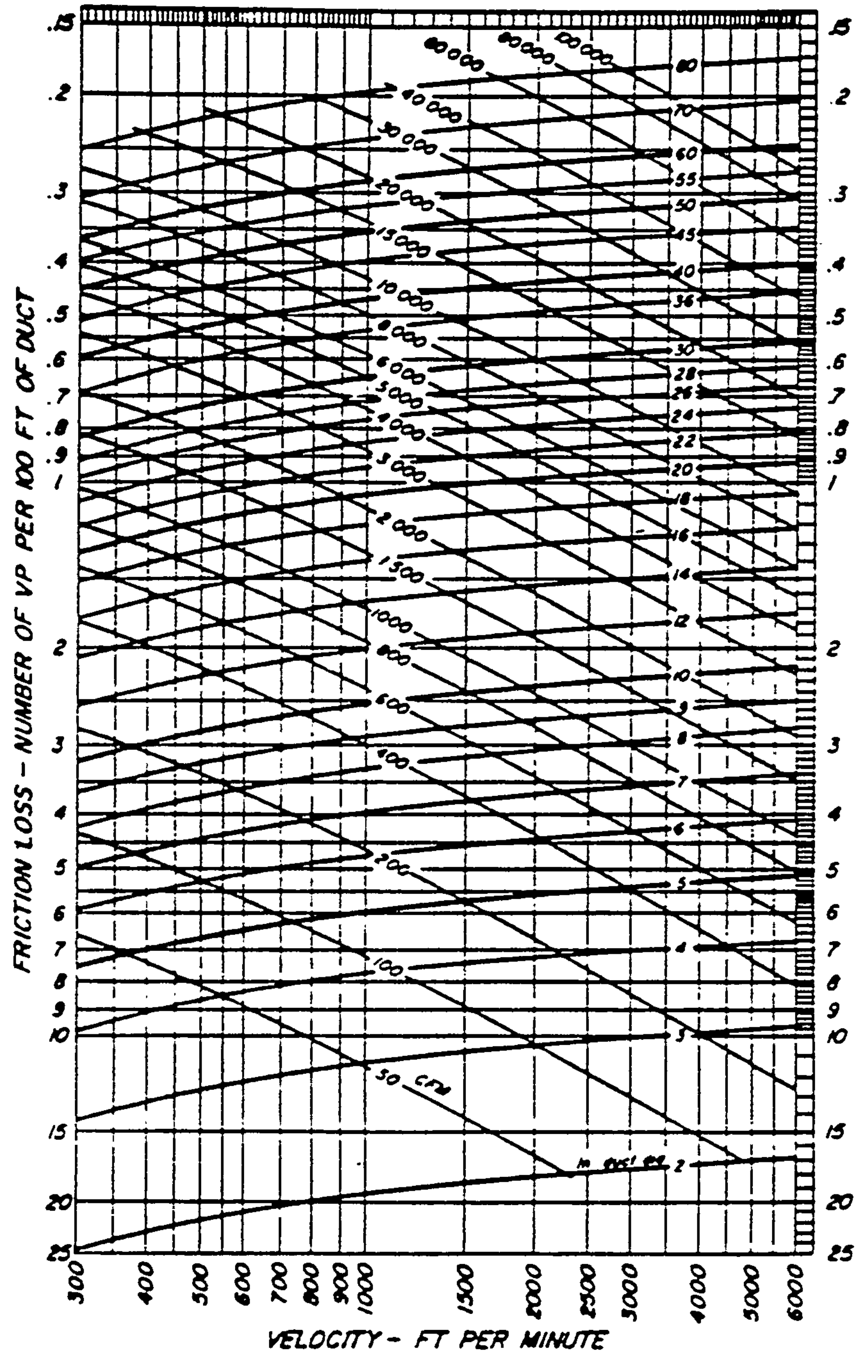
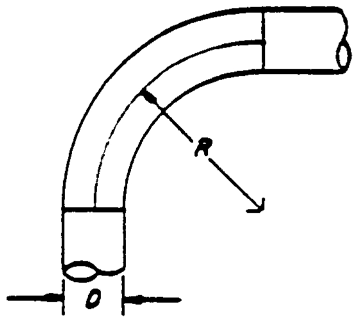


Figure 1- DUCT FRICTION LOSS
for round ducts expressed as velocity
pressure equivalents per 100 feet of duct.



R, No. of Diameters	Loss Fraction of VP
2.75 D	0.26
2.50 D	0.22
2.25 D	0.26
2.00 D	0.27
1.75 D	0.32
1.50 D	0.39
1.25 D	0.55

ROUND ELBOWS

Figure 2 —

ELBOW PRESSURE LOSS
for round duct elbows.
(reprinted from the ACGIH Industrial Ventilation Manual).

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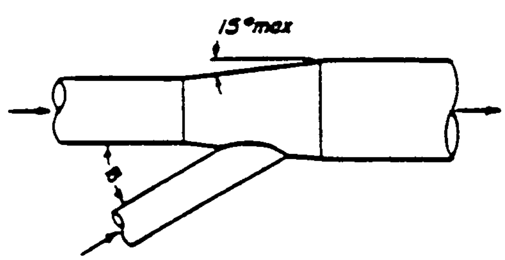
DUCTWORK DESIGN DATA

DATE 1-66



Note: Branch entry loss assumed to occur in branch and is so calculated.

Do not include an enlargement regain calculation for branch entry enlargements.

Angle θ Degrees	Loss Fraction of VP in Branch
10	0.06
15	0.09
20	0.12
25	0.15
30	0.18
35	0.21
40	0.25
45	0.28
50	0.32
60	0.44
90	1.00

BRANCH ENTRY LOSSES

Figure 3 —

BRANCH DUCT ENTRY PRESSURE LOSS
(reprinted from the ACGIH Industrial Ventilation Manual).

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DUCTWORK DESIGN DATA

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E. LOCAL EXHAUST VENTILATION EQUIPMENT

This section includes typical hoods commonly used in welding operations.

FREELY SUSPENDED HOODS

A freely suspended hood is a moveable type hood often connected to a flexible duct and/or a swivel joint which may have a round, square or rectangular shaped hood face. Figure 4 below shows this concept and provides design information.

$$Q = K(10x^2 + A)V_x$$

- Q = exhaust volume, cfm
- x = distance from center of hood face to furthest point of contaminant release, ft.
- A = hood face area, sq. ft.
- K = 0.75 for flanged hood,
- K = 1.0 for unflanged hood.

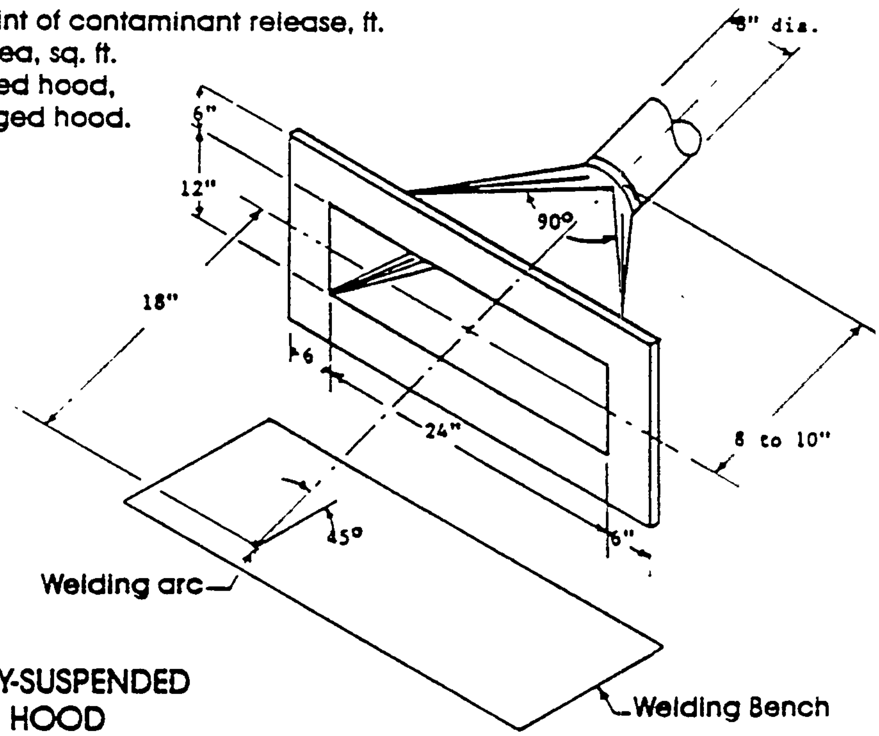
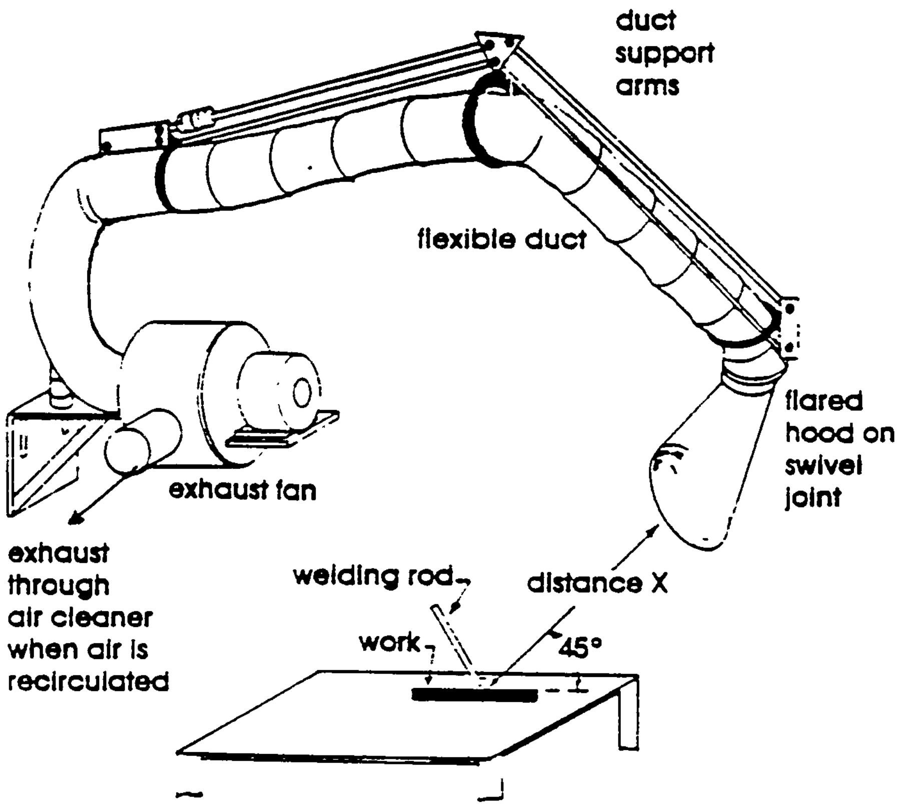


Figure 4 — FREELY-SUSPENDED OPEN HOOD

Recommended Rectangular Hood Performance for Shielded Manual Metal Arc Welding:	8ase Metal Carbon steel	Stainless steel
V_x (fpm) at distance x = 18″	20	100
Q (cfm) volume of air flow		1734
V (fpm) air velocity at face	182	870
VP (in. w. gage) vel. pressure, face	n.a.	0.05
V in duct (tpm)	(1100-2000)	4950
VP in duct (In. w. gage)	0.07	1.53
Entry loss factor x VP in duct	0.17	0.12

The Fume Collector with exhaust fan shown in Figure 5 below has a movable hood to a flexible duct mounted on a pivoting elbow. The weight of the hood and duct Is balanced by weights, springs, and friction at the pivots. Approximately six companies provide this type of movable hood. These companies are listed in a partial list of equipment suppliers in Appendix 1.



face Velocity = 1500 fpm
Duct velocity = 3000 fpm minimum
Enhy Loss = 0.25 duct VP

RELATlONSHIP BETWEEN DISTANCE, X (Inches) and FLARED HOOD EXHAUST AIR VOLUME (cfm)

X, Inches	Hood Exhaust, cfm
UP to 6	260
6-9	560
9-12	1000

Figure 5- MOVABLE EXHAUST FUME HOOD

2. CROSSDRAFT TABLE

The crossdraft table is a welding bench with a slotted exhaust on the side opposite from the welder. The minimum exhaust volume through the hood is in accordance with the formula:

$$Q = KLWV_x$$

where Q = exhaust volume, CFM
W = table width; ft, not to exceed 4 ft.
L = table length, ft.
V_x = minimum capture velocity, fpm
K = 2.4 with baffles at each end of the table; and 2.8 without baffles. Baffies are desirable.

Entry loss = (1.78x slot VP) + ((entry loss for tapered hood) x (duct VP))

Recommended Duct velocity is 2000 fpm or greater. Figure 6 shows the crossdraft tabie.

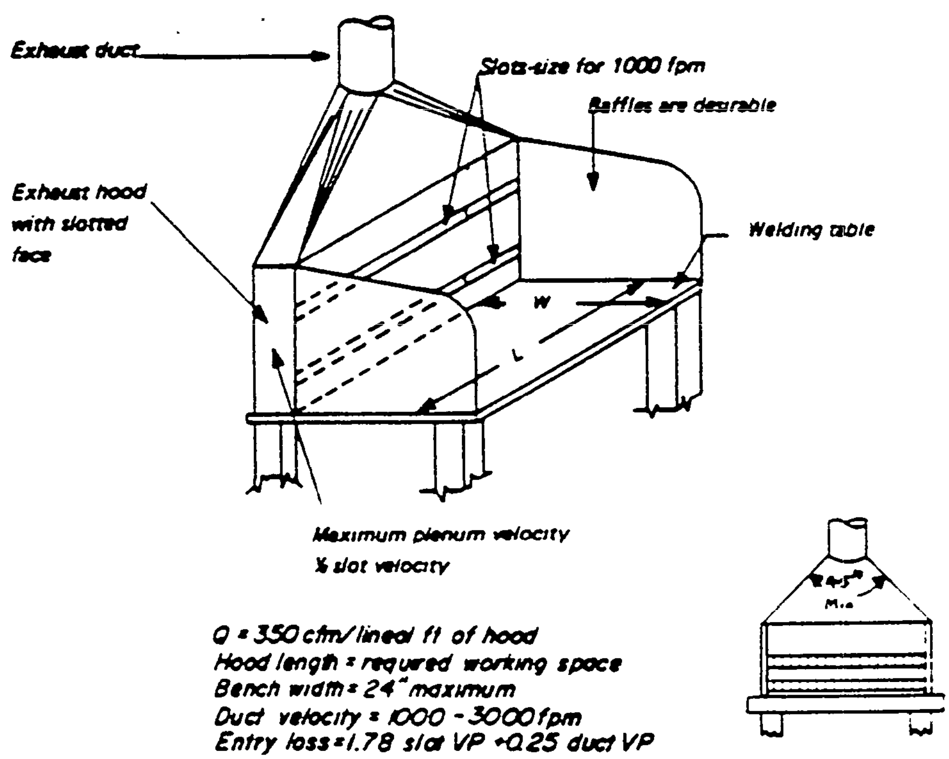
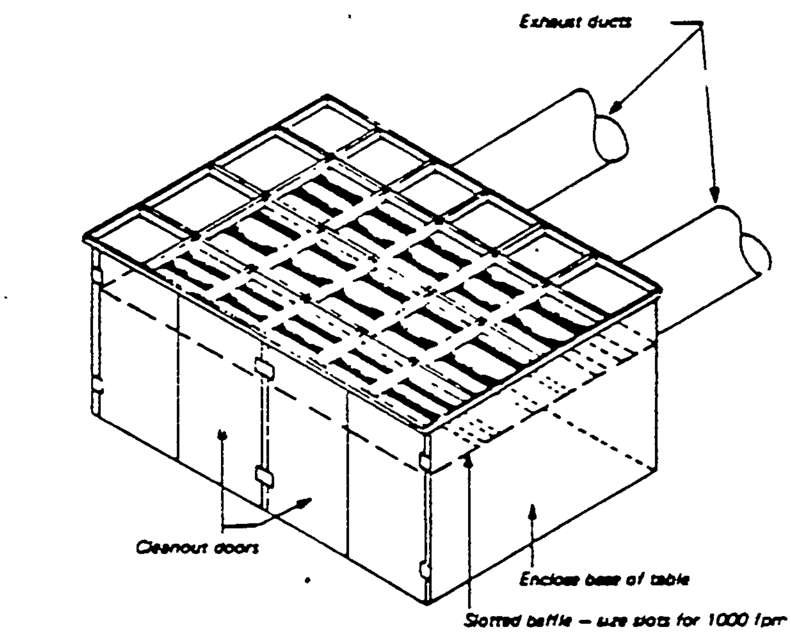


Figure 6- CROSSDRAFT TABLE

Movable exhaust hoods of the type shown in Figures 4 and 5 and the crossdraft welding bench shown in Figure 6 are two very useful ways to exhaust welding fumes for a large variety of welding jobs. Metal spraying requires a more specialized hood shape of an open hood type shown in Figure 9. Some types of welding and grinding work can be controlled better by the use of a downdraft table shown in Figure 7. The enclosing hood of Figure 8 is a method of completely isolating welding operations from other work areas. Another type of welding fume control is the use of a gun mounted hood incorporated into a welding gun. A schematic of this is shown in Figure 10.

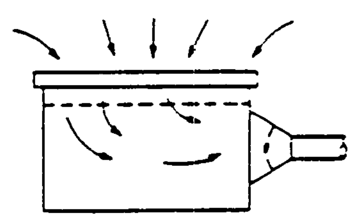
3. DOWNDRAFT TABLE

A downdraft table uses a grill both to support the item being welded and to serve as the face of a hood to exhaust air to a branch duct. Minimum velocity at the face of the grill is 150 fpm or greater. The item being welded is positioned so that the contaminant is released vertically and not horizontally. The work is located so that the contaminant source is not higher above the grill than a distance which is 1/4 or less of the shortest dimension of the grill hood face opening. Figure 7 is a downdraft table with design data. This method applies to special conditions, and requires careful attention to detail to be used correctly. (Use of the downdraft table could result in a sizeable investment without getting satisfactory results.)



Duct velocity = 2000 fpm minimum

$$Q = A \times V_f$$



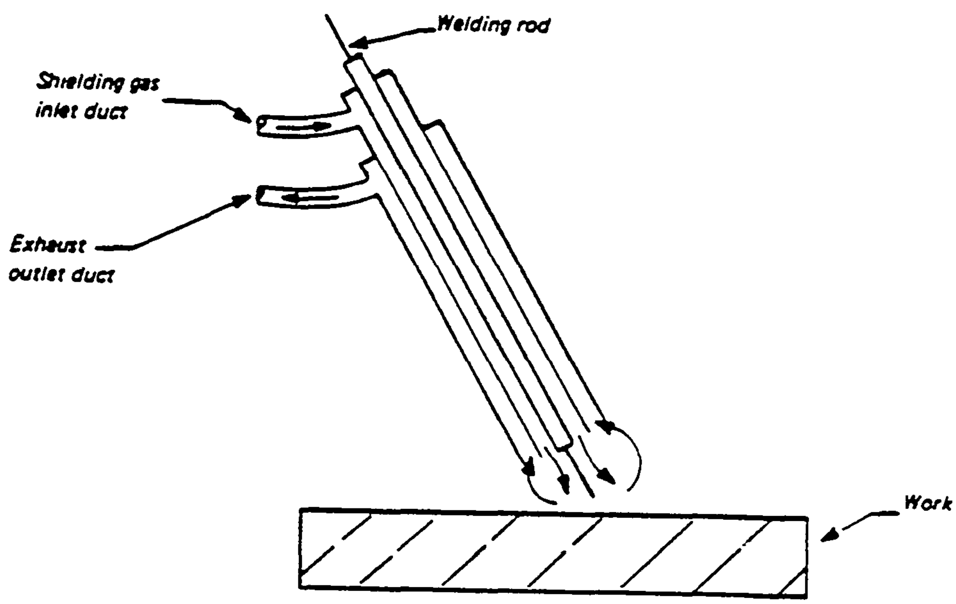
Q = exhaust volume, cfm
A = table top area, sq. ft.
V_f = minimum face velocity, fpm
Entry loss = 1.78 slot VP + entry loss factor for tapered hood × duct VP.

Figure 7- DOWNDRAFT TABLE

6. GUN-MOUNTED EXHAUST HOOD

The gun-mounted exhaust hood is incorporated into the welding gun. A general formula for exhaust flow has not been published because the hoods vary in design. The exhaust volumes are generally established jointly between user and manufacturer specifically for each type of welding operation. Figure 10 is a diagram of the welding gun-mounted exhaust hood.

Exhaust flow requirements must be determined for each welding operation and welding gun configuration by experimental testing with air contaminant sampling and analysis.



Exhaust flow requirements must be determined for each welding operation and welding gun configuration by experimental testing with air contaminant sampling and analysis.

Figure 10- HOOD MOUNTED ON WELDING GUN

7. EXAMPLE DESIGN CALCULATION, WELDING BENCH HOOD

The example calculations below follow basic airflow relationships for ventilation ducts from Section D.7. They provide relationships specifically applicable to airflow in a welding hood design.

a) Choose hood type, air flow rate, and duct layout.

For this example use a single slot variation of the welding bench, Figure 6- Crossdraft table which gives the hood entry loss as:

Entry Loss = 1.78VP slOt + 0.25 VP duct.

Design data in Figure 6 recommends 350 cubic feet per minute (CFM) air volume per foot of bench.

Using a bench 3 feet long (by *2* feet wide) gives an air volume of:

Q = 350 CFM/foot X 3 feet = 1050 CFM

Use a slot velocity of 1000 fpm, a plenum velocity = 1/2 slot velocity, and a duct velocity of 2000 fpm. Use two horizontal slots, each 2″ high by 3 feet long.

Assume an exhaust duct rising 25 feet long vertically from the hood bending in a 90° elbow to go horizontal for 7 feet to an exhaust fan leading to an 8 feet vertical exhaust duct.

b) The calculation continues as follows:

1. Vertical Duct 25 ft. long from hood

2. Air Volume, Q = 350 CFM X 3=I050CFM

3. Slot area = 2 slots x 2″ high x $\frac{1}{12'' \text{ per ft.}}$ x 3 ft. wide = 1 Sq. ft.

4. Slot velocity = $\frac{\text{Q air volume}}{\text{Sq. ft. slot area}}$. $\frac{\text{1050 CFM}}{\text{1 Sq. ft.}}$ = 1050 fpm

5. Slot velocity pressure, VP_s = 0.07 in. w.g. for 1050 fpm, from

$$VP_s = \left(\frac{\text{Velocity}}{4005}\right)^2$$

6. Slot entry loss = 4.78 VPs

7. Acceleration factor is normally 1.0 V.P. for slot velocity greater than duct velocity it is zero when duct velocity is greater than slot velocity.

8. Entry Loss= 1.78 VPs + 0 = 1.78 VPs slot = 4.78 x 0.07= 0.125 in. w.g.

9. Duct diameter for 2000 CFM velocity is found from

$$A = \frac{Q}{V} = \frac{1050\ CFM}{2000\ fpm} = 0.53\ Sq.\ ft.$$

10. A 10 inch diameter is an area of 0.5454sq. ft. $\frac{1050 CFM}{0.5454\ Sq.\ ft.} = 1{,}925$ fpm duct velocity. if a minimum duct velocity of 2000 fpm was required, then the next smaller duct diameter of 9½ inches would be chosen with an area of 0.4923 sq. ft.

11. This results in a

$$\text{Duct Velocity} = \frac{1050\ CFM}{0.4923\ Sq.\ ft.} = 2133\ fpm$$

12. Duct velocity pressure,

$$VP_d = \left(\frac{2133}{4005}\right)^2 = 0.284\ in.\ w.g.$$

13. Hood static pressure loss = slot entry loss + transition entry loss + VP duct

(1.78 x 0.07) + o.25VPd + VPd = 0.125 + (0.25 x 0.284) + 0.284= 0.48in.w.g.

14. The total duct length from hood to fan is 25 + 7 = 32 feet with one 90° Elbow.

15. A straight duct Friction factor using 91/2 inch dia. and 2133 fpm velocity, from Figure 1 is = 2.5 VPd per 100 feet of duct.

16. The actual straight duct friction factor for the 32 foot length from hood to fan is:

$$\frac{32\ ft.}{100\ ft.} \times 2.5\ VP\ loss\ per\ 100\ ft. = 0.80\ VP_d = 0.27$$

The actual straight duct friction factor for the 8 foot duct from fan to outside exhaust is:

$$\frac{8\ ft}{100\ ft.} X\ 2.5\ VP = 0.20\ VPd = 0.057$$

17. Figure 6 of the cross-draft welding bench gives the duct loss fat. for as 0.25 duct VP, for the 32 foot duct. The 8 foot section of exhaust duct has no hood so no loss of this type takes place for this duct.

18. An “Acceleration Factor” is energy needed to accelerate room air up to the hood duct velocity. This is always equal to 1.0 VP for the 32 foot duct. The 8 ft. section has no hood and no acceleration factor.

19. The Elbow loss factor= 4 x 0.27x VP loss of one elbow = 0.27 VPd = 0.077

20. in a more complex system the Entry Loss Factor of a branch duct into a main duct would be considered. .

21. Also in a more complex system, special fitting losses would be considered for air cleaners and other non-standard items.

22. The total duct loss factor is the sum of calculation steps 16,17,18, 19,20 and 21. Static pressure loss is loss factor times VPd.

For the 32 foot duct this is:

$$VPd\ (0.8 + 0.25 + 1.0 + .27) = 2.32\ VPd = 0.66 \text{ in. w.g.}$$

and for the 8 foot duct is:

$$VP_d\ (0.20 + 0 + 0 + 0) = 0.20\ VP_d = 0.06 \text{ in. w.g.}$$

23. At this point any other losses, if any, would be inserted.

24. Total Duct SP losses are

For 32 ft. duct = plenum SP (if slot hood) + duct SP + other losses
= 0.48 (from step #13) + 0.66 (from step #22) + 0

SP = 1.14 in. w.g.;

For 8 ft. duct

SP = 0 + 0.06 + 0 = 0.06 in. w.g.

25. At this point the branch duct SP and main duct SP would be compared in a more compiex system, and the larger SP taken as the governing static pressure.

$$\text{CFM corrected} = (\text{CFM, lower}) \times \frac{(\text{SP, higher})}{(\text{SP, lower})}$$

27. Rechecking the hood calculation: The Hood Static Pressure is the suction needed in the duct by the hood to overcome acceleration and hood entry losses. it is usually calculated from the previous calculations and used for balancing airflow in the system after installation. it equals the sum of the hood entry loss and the acceleration loss times the velocity pressure.

Hood Static Pressure = (hood entry loss, step #17 + acceleration loss of 1.0 VP) x (VP duct, step #12 + Entry Loss, step #8.

Hood SP = (0.25 + 1.0) x (0.284) + 0.12 in. w.g.
= 0.36 + 0.12 = 0.48 in. w.g.; this checks with step #13.

28. Fan static pressure is the static pressure the fan must generate to overcome the total resistance in the system.

Fan SP = Hood SP + SP 32′ duct loss + SP 8′ duct loss - VP fan inlet.

FSP = 1.44 (calc. step #24) + 0.06 (calc. step #24) -0.284
(talc. step #12)

FSP = 0.916 in. w.g.

This crossdraft welding bench with 32 foot duct to fan, and 8 foot duct from fan to outside exhaust would be built using a 91/2 inch diameter duct, and a fan that will provide 1050 cubic feet per minute (CFM) at 0.916 inches of water gauge fan static pressure.

F . VENTILATION SYSTEM EVALUATION

in this section, methods are outlined to evaluate whether an existing ventilation system is operating adequately and meeting design requirements. This question usually arises after air sampling indicates there is a problem, or an experienced observer sees something wrong.

1. BASIC RELATIONSHIPS BETWEEN AIR VELOCITY, PRESSURE AND VOLUME FLOW RATE

The air velocity needed to capture and transport fumes, dust, or other industrial contaminants is found in tables in various published documents. The rate of air flow volume is calculated from the rquired

duct or capture velocity, and the cross-sectional area of the duct or exhausting hood by:

$$\text{Air Flow Volume Rate (Q)} = \text{Duct Velocity (V)} \times \text{Area (A)}$$

The units used in the above equation are:

$$\text{Cubic feet per minute (CFM)} = \text{Feet per minute (fpm)} \times \text{Sq. Feet}$$

The capture velocity decreases rapidly as the distance from the face of the hood Increases. The air velocity at some distance from the face ‘of a hood (round hoods and essentially square hoods) can be determined from the relationship:

$$\text{Capture Velocity (CV)} = \frac{\text{Air Flow Volume Rate (Q)}}{10\ (\text{Distance, } (X)^2 + (\text{Area of Opening, A})}$$

The distance, X, is taken at a right angle from the center of the hood face. This relationship applies only for a limited distance of up to 1.5 times the diameter of a round hood or the length of one side of a square hood.

The size of the ducts and exhaust fan are determined from pressure drops caused by friction and turbulence of the air as it moves inside hoods, ducts, elbows, duct transitions,. and the air cleaner.

Moving air creates a pressure, called velocity pressure, which is usually measured in inches of water with a manometer. The relationship is:

$$\textbf{Air Velocity, feet per minute} = 4005\ \sqrt{\text{Velocity Pressure, " w.g.}}$$

When the temperature of the air stream is greater than 30° from a standard 70° temperature, or when the local elevation is more than 1,000 feet, then a correction for air density should be made in the above formula. In this case, the relationship is:

$$v = 1096\ \sqrt{\frac{VP}{(0.075 \times \text{relative air density})}}$$

The relative air density for various temperatures and altitudes can be corrected from density correction factors available in tables.

The velocity pressure (VP) is always positive and exerted in the direction of air flow. VP is a measure of the kinetic energy in the system.

Air confined within an enclosure (such as a hood or duct) creates another type of pressure perpendicular to the walls of the enclosure. This pressure is called Static Pressure (SP, inches of water in a manometer). SP exists whether the air is in motion or not and is normally independent of the velocity of the air. When the static pressure (SP) is below atmospheric pressure, it is negative. SP is positive when above atmospheric pressure.

The Total Pressure (P, inches of water) in a hood or duct is the algebraic sum of Static Pressure and Velocity Pressure.

$$TP = VP \# SP$$

Air flowing through a duct results in a pressure drop from resistance to flow. The resistance is generated by:

a) Friction losses from air molecules rubbing against the inside of the duct surface, and

b) Dynamic (turbulence) losses from changes in air flow direction or air velocity.

The sum of the static pressure plus velocity pressure (SP + VP) upstream in a duct is equal to (SP + VP downstream added to friction and dynamic losses.

Total Pressure upstream = Total Pressure downstream + Friction & dynamic air flow losses

2. TESTING AND MAINTENANCE

Periodic checking of airflows in a ventilation system is needed to do the following:

- Assure that the operation is within acceptable limits

- Diagnose malfunctions

- Determine what maintenance or repairs may be necessary

Testing consists of making airflow measurements, organizing the data, and analysis to determine if corrections in the operation are needed. A permanently mounted air velocity gauge is recommended for monitoring and control.

a) Evaluation is done by determining the following physical conditions:

1] Static pressures at hoods and upstream and downstream from the air cleaner and fan,

2) Air voiume flow rates at hoods, ducts, branches, main ducts, upstream and downstream from the air cleaner and fan,

3) Air velocities in hoods, branches and main ducts,

4) Fan speed, horsepower, and power consumption.

b) TEST MEASUREMENTS should be recorded and accompanied by a sketch of the hoods, ducts, elbows, air cleaner, plenums, fan and stack. The documentation should include the nature and concentration of materials being controlled and the type and frequency of maintenance.

c) INSPECTIONS should include review of changes in test data measurements and visual observation for items such as:

1) Reduced fan output because of beit slippage, worn rotor, or build-up on fan blades.

2) Excessive build-up or any visible damage of the air fiter,

3) Accumulations of material in duct elbows, branches and main duct,

4) Changes in blast gate settings if the system is balanced using blast gates.

The Pilot tube is the standard for measuring air velocity. A typical Pitot tube does not need calibration and is most suitable for accurate field work. The Pilot tube is used with a manometer to provide readings in inches of water gauge.

The air velocity distribution across the diameter of a duct is usually not uniform because of turbulent and stratified layers of airflow. Measurements are made at a number of points across the duct diameter to determine the average velocity. This is done by making two traverses perpendicular to each other with a Pitot tube to obtain calculated average velocity pressures. The measured velocity pressures (VP) are converted to airflow velocities. The velocities are then averaged. Do not average the VP and convert this to an erroneous

average velocity. However, the square root of each VP measurement may be taken, then these can be averaged and converted to a correct average velocity.

3. STATIC PRESSURE ANALYSIS

When something happens to a ventilation system such as a loose fan belt or partial plugging of a duct, the hood draws less air. This is readily checked by measuring the static pressure with a manometer gauge. The rate of airflow is directly proportional to the square root of hood static pressure.

The static pressure in the hood is best measured in the exhaust duct approximately one duct diameter away from the hood. The hole in the duct for measuring static pressure (SP) with a manometer must be smooth on the interior wall of the duct. Any burrs or protruding edges cause turbulent air flow, with increasing velocity and lowered hood statlc pressure readings.

Measurements at other points in ductwork on either side of the fan and air cleaners, or near branch junctions, should be made several diameters away from turbuient areas. Design SP’s may be obtained from system plans, or estimated.

The following examples indicate how static pressure (SP) tests can help diagnose problems:

a) If hood static pressure (SP) is low on ail hoods but high between fan and air cleaner, then the air cleaner should be checked.

b) If hood SP readings are low on all hoods but readings on both sides of the air cleaner are above normal, then the main duct or branch duct may be partially plugged (if air cleaner is ahead of fan).

c) If the hood SP readings are low and also the SP on both sides of the air cleaner are low, then one of the following exists:

- fan is not working properly
- discharge stack is plugged, or
- duct joint may be loose.

d) if all SP readings are normal except that one hood SP is low, the branch duct between the low SP readings and the main duct maybe plugged.

e) If all SP readings are normal except one hood SP is high, a blockage probably exists between the hood opening and the SP test location.

f) If all SP readings are near normal except SP readings in two adjacent hoods are low, then the main duct is probably plugged near the two hoods with low SP readings.

4. FAN PERFORMANCE

Fans do not need much attention except for periodic maintenance as long as the system is operating properly. If power consumption is higher than it should be, if decreased airflow through hoods is attributed to poor fan performance, or if additions to the ventilation system are being considered, tests of fan performance may be necessary.

Fan performance can be seriously affected by spinning airflow at the fan inlet. Fans are rated by the manufacturer assuming that the air entering the fan is moving in a straight line. If an elbow or other disturbance causes spinning airflow, the fan will not work as expected.

The only way to detect spinning flow is with a Pltot tube. Insert the tube into the duct near the fan and rotate it slowly up and down, and back and forth at different points within the duct. The maximum velocity pressure reading occurs when the Pitot tube is facing directly into the air stream. If maximum readings are found with the Pitot tube pointed slightly upward on one side of the duct and downward on the other side of the duct, the approximate angle of spin can be estimated. Retest the system after flow straighteners or elbow turning vanes have been installed to see if the condition has been corrected.

Before working around a fan, review and be careful of the following conditions:

a) Air blasts from fan outlets or exhaust stacks can cause injury.

b) Do not open fan access doors while the system is running. On the fan outlet side, the doors could open with explosive force.

c) Close all access doors before starting the fan motor. An open door on the suction side of the fan can overload the motor during starting as well as creating a suction hazard.

d] If a fan motor belt drive guard must be removed to measure rotating speed, beware of entangling long hair, ties, etc. in rotating machinery.

e) Whenever the fan is operated with a guard removed or ducts disconnected, clear the area of unauthorized personnel and post signs or guards to keep bystanders away.

A fan rating curve obtained from the manufacturer for the model and size of fan at the installed operating speed and air density will help in determining if the fan is operating in the desired range, or indicate what corrective changes can be made.

A good fan test begins with a pitot traverse of a straight duct section near the inlet to find duct velocity and airflow into the fan. Fan inlet velocity is important because the velocity pressure at the fan inlet represents kinetic energy already in the system. This is used to identify spinning air patterns at the fan inlet (as described under pitot veiocity measurements eariier). Other tests include:

a) Measure air temperature in the system, check the amount of elevation above sea level to see if air density corrections are needed for nonstandard air ranges as discussed in previous sections.

b) Measure air temperatures at four places around the inlet duct to the fan. Differences greater than 20°F indicate the air entering the fan is separated into different temperature zones which can reduce fan performance.

c) Measure the rotating speed (RPM) with a tachometer and check the fan rating curve for this speed.

d) Measure fan inlet and outlet static pressures using either a static tap in the duct wall or the static pressure arm of a Pitot tube connected to a manometer. The static readings should be corrected for nonstandard air density if needed. With these readings plus the fan inlet velocity, calculate fan static pressure.

Fan SP = outlet SP - inlet SP - inlet Velocity Pressure
(note: outlet SP usually +, inlet SP usually -, VP always +)

e] Determine the volts and amps being applied to the fan motor. Usually the maintenance electrician will have access to a clamp-on ammeter-voltmeter. if motor efficiency and power factor data are not available, then check if the motor is operating within the specified amp and volt rating on the nameplate.

5. FAN HORSEPOWER

The brake horsepower (BHP) of the fan can be calculated from Total Fan Pressure (TP), volume flow rate of air Q (CFM), and fan mechan-

Ical efficiency (ME) which usually ranges from 0.50 to 0.65. The relationship is:

$$BHP = \frac{Q \times TP}{6356 \times ME}$$

If the motor efficiency (E) and power factor (PF) can be obtained from the manufacturer, then the brake horsepower (BHP) can be calculated from the measured volts (V) and amps (A) from the equation:

$$BHP = \frac{4.73 \times volts \times amps \times E \times PF}{746}$$

6. SYSTEM EVALUATION SUMMARY

Step #1 Obtain all design data on system, fan, and air cleaner

Step #2 Sketch Layout of system with dimensions

Step #3 Check Static Pressure at: Hoods
Upstream of fan
Downstream of fan
Upstream of air cleaner
Downstream of air cleaner
Other points in ducts as needed

Step #4 Measure Velocity Pressure or air velocity in branches, up stream and downstream of fan and collector, using Pitot tube traverse and calculate flow volumes.

Step #5 Measure Capture Velocity at hoods.

Step #6 Evaluate Fan: Inlet temperature
RPM
Volts and Amps
Calculate BHP

Step #7 Check blast gate settings, if any.

Check air cleaner for: Dirty filters
Proper seals
Visible damage

Check all ductwork for damage or leaks

Check angle of entries to junctions

Check radii of elbows and transition sections.

Step #8 Check ail data found against design information or system requirements.

7. VENTILATION EVALUATION EQUIPMENT

Equipment needed: Pltot tube and pressure instruments
Rotational speed measuring device
Air velocity meter
Diameter tape
Thermometer

Photographs help supplement any sketches that are made.